California Energy Commission

Lead Comissioners Workshop on California Nuclear Power Plant Issues

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Central Coastal California Seismic Imaging Project
Technical Manager

June 19, 2013

Nuclear Power Plant Data Request

Progress in Completing AB1632 Report/ 2008 IEPR

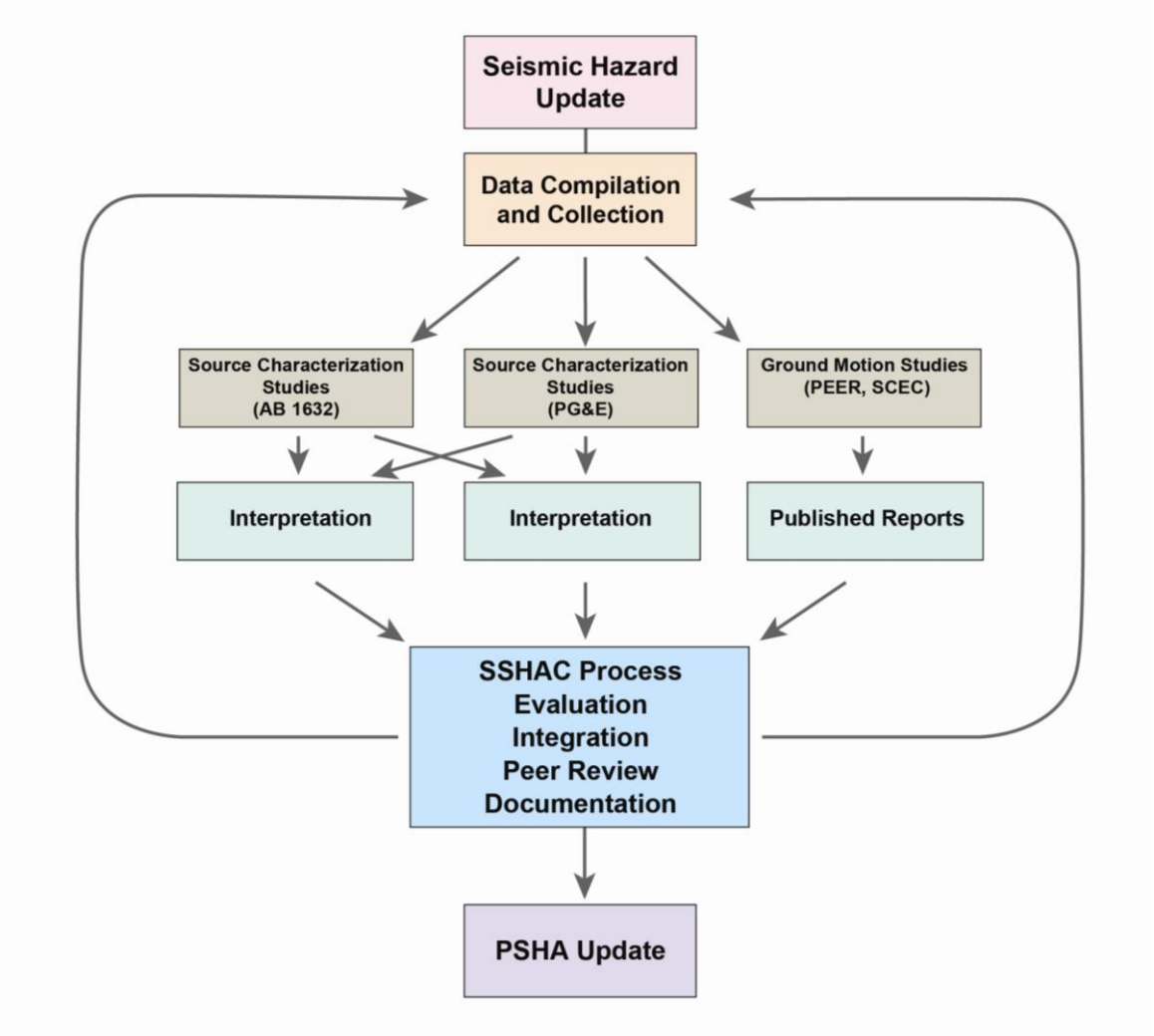
A. Seismic Hazards at Diablo Canyon

1. Please report on the overall status of ongoing efforts to understand seismic hazards affecting the Diablo Canyon site through its Long Term Seismic Program (LTSP) and the results of research efforts.

The Seismic Hazard Update currently underway at DCPP follows Senior Seismic Hazard Analysis Committee (SSHAC) Level 3 process[1] that is scheduled to be completed in March 2015

1- *NUREG-2117 Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies.*

DCPP Seismic Hazard Update



Seismic Source Characterization

LTSP Tectonic Model

Marine Data

- Multi Beam Echo Sounding (MBES) Mapping
- 2D/3D Low Energy Seismic Reflection Surveys

Onshore Data

- 2D/3D Seismic Reflection Surveys
- Geologic Mapping
- Light Detection and Ranging (LiDAR) Mapping

Potential Field Mapping (gravity, magnetics)

Ground Motion Characterization

Next Generation Attenuation (NGA) Ground Motion Model

- Ground Motion Data Base
- NGA West2 Model Updates

Numerical Models

- Dynamic Rupture Models
- Finite Fault Simulations

A. Seismic Hazards at Diablo Canyon

2. Please discuss whether updates to ground motion models developed to date through the Senior Seismic Hazards Analysis Committee (SSHAC) Level 3 process indicate larger than expected seismic hazards at Diablo Canyon and, if so, whether the plant was built with sufficient design margins to continue operating reliably after experiencing these larger ground motions (Diablo Canyon).

The DCPP SSHAC Level 3 study is scheduled to be completed in March 2015

Progress in Completing 2011 IEPR Recommendations

A. Seismic Issues

1. Please provide an update on the progress in completing the AB1632 Report recommended seismic studies, including technical details and any significant updates of seismic hazard study plans completed, in progress or proposed since 2011 (as recommended in the 2008 IEPR Update) and the associated findings as applicable.

California Energy Commission

An Assessment of California's Nuclear Power Plants: AB 1632 Report

- Recommended that PG&E and Southern California Edison update their seismic hazard assessments
- Use 3D geophysical seismic reflection mapping and other advanced techniques to supplement previous and ongoing research programs

On January 10, 2010 PG&E filed Application (A.)10-01-014 with the CPUC for cost recovery of $16.73 million associated with enhanced seismic studies recommended by the CEC AB1632 Report.

The CPUC issued Decision (D.) 10-08-003 to perform these additional studies on August 12, 2010.

On September 23, 2011 PG&E filed a motion to reopen A.10-01-014 to request additional funding for increased costs of the enhanced seismic studies at DCPP.

The CPUC issued D.12-09-008 authorizing PG&E to recover in rates an additional $47.5 million above the $16.73 million already approved in D.10-08-003 for a total of $64.25 million.

AB 1632

2010 – 2013

California Public Utilities Commission

Independent Peer Review Panel

CA Coastal Commission

Cal EMA

CA Energy Commission

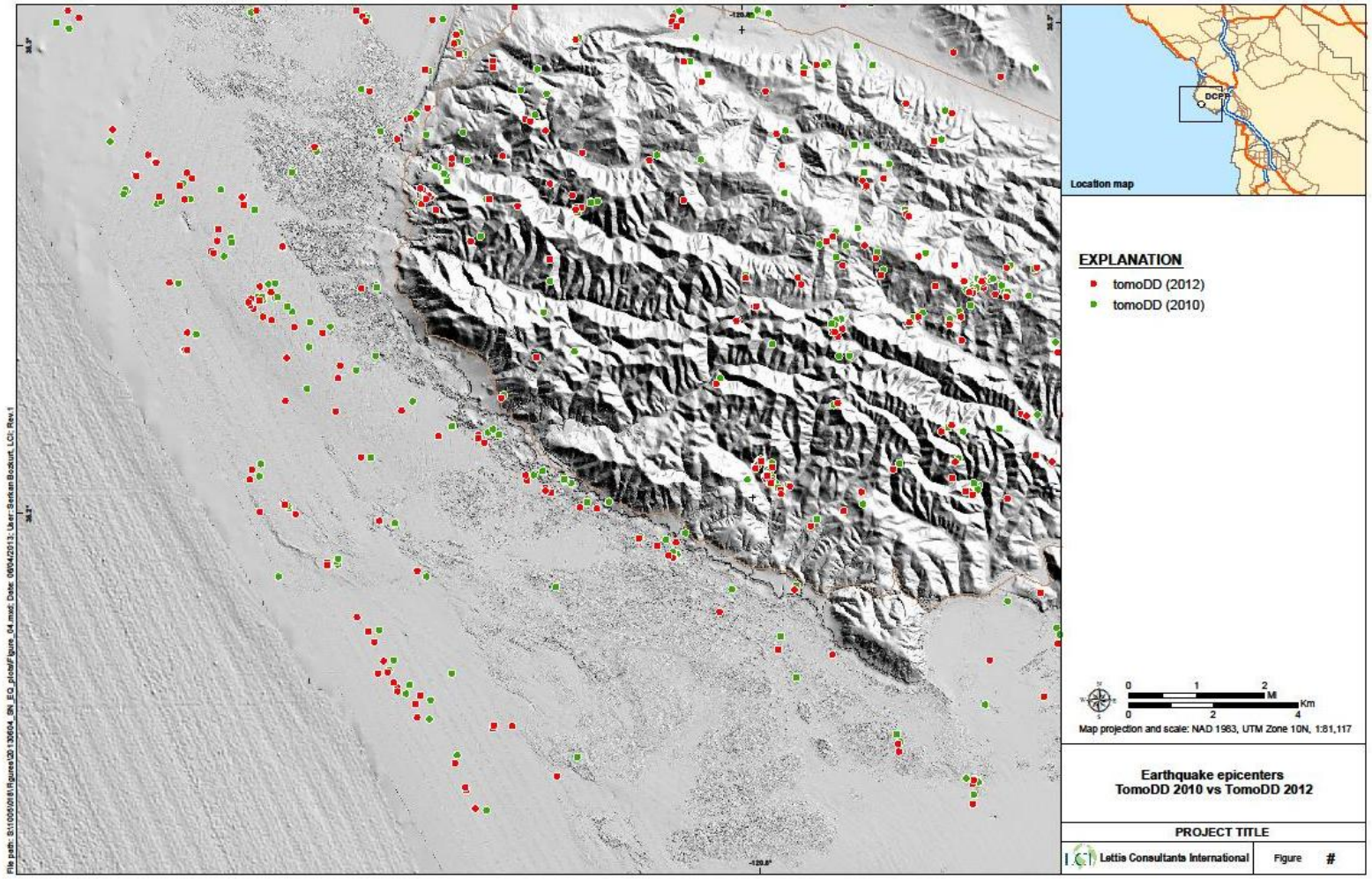
CA Geological Survey

CA Public Utilities Commission

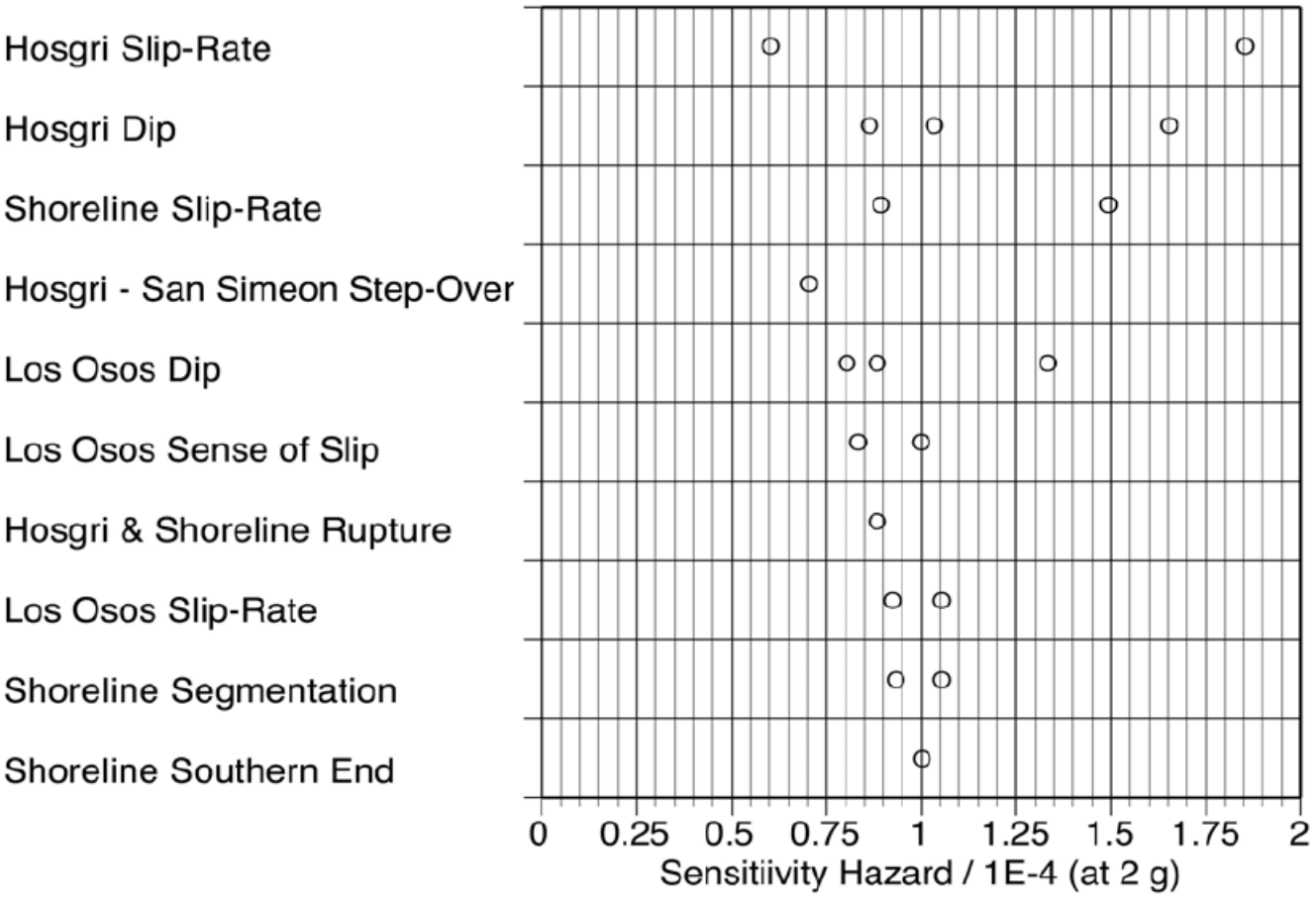
CA Seismic Safety Commission

County of San Luis Obispo

Seismicity 1987-2012



Seismic Source Characterization Sensitivity Study

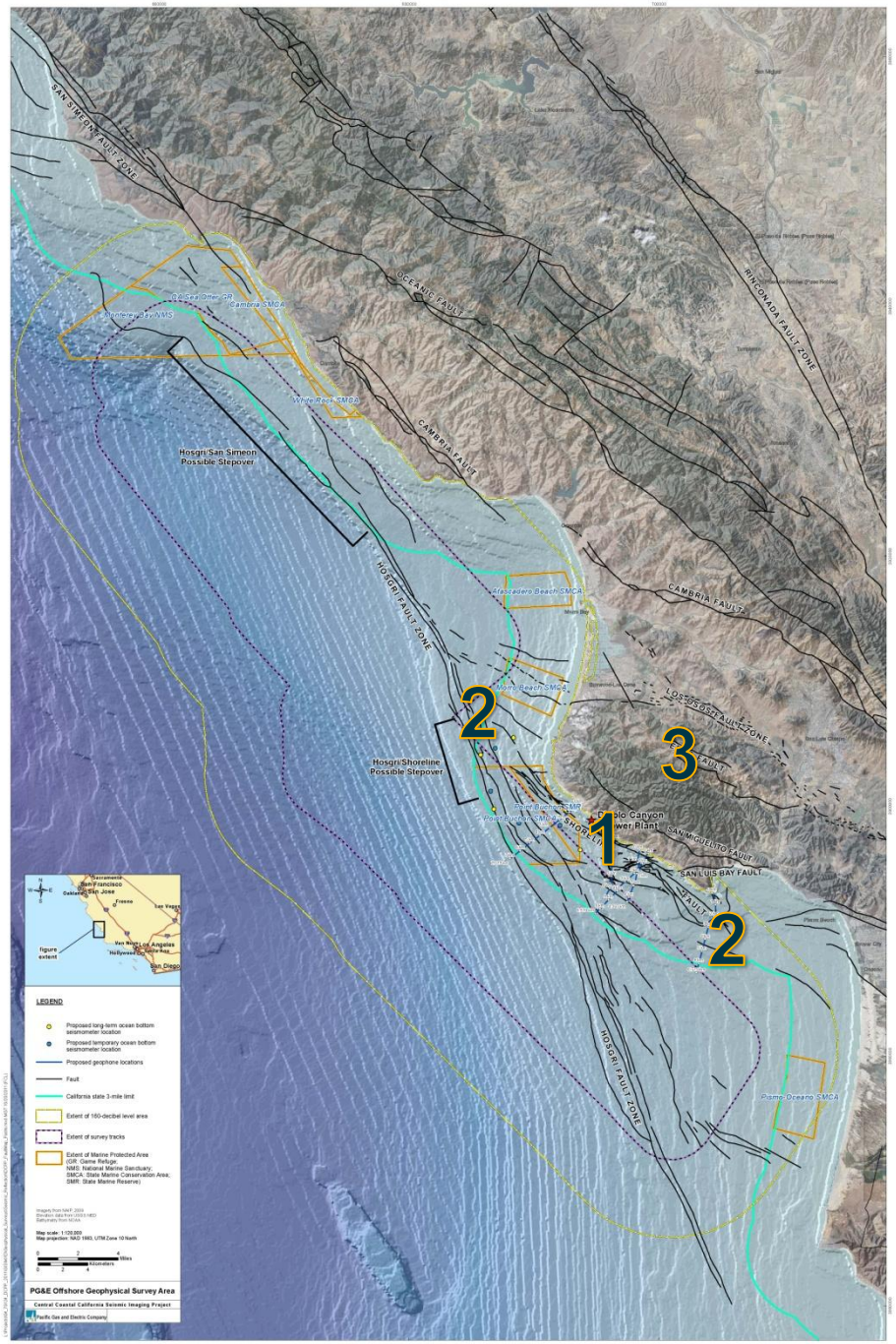


Central Coastal California Seismic Imaging Project 2009-2011

1. Multi Beam & Potential Field Mapping

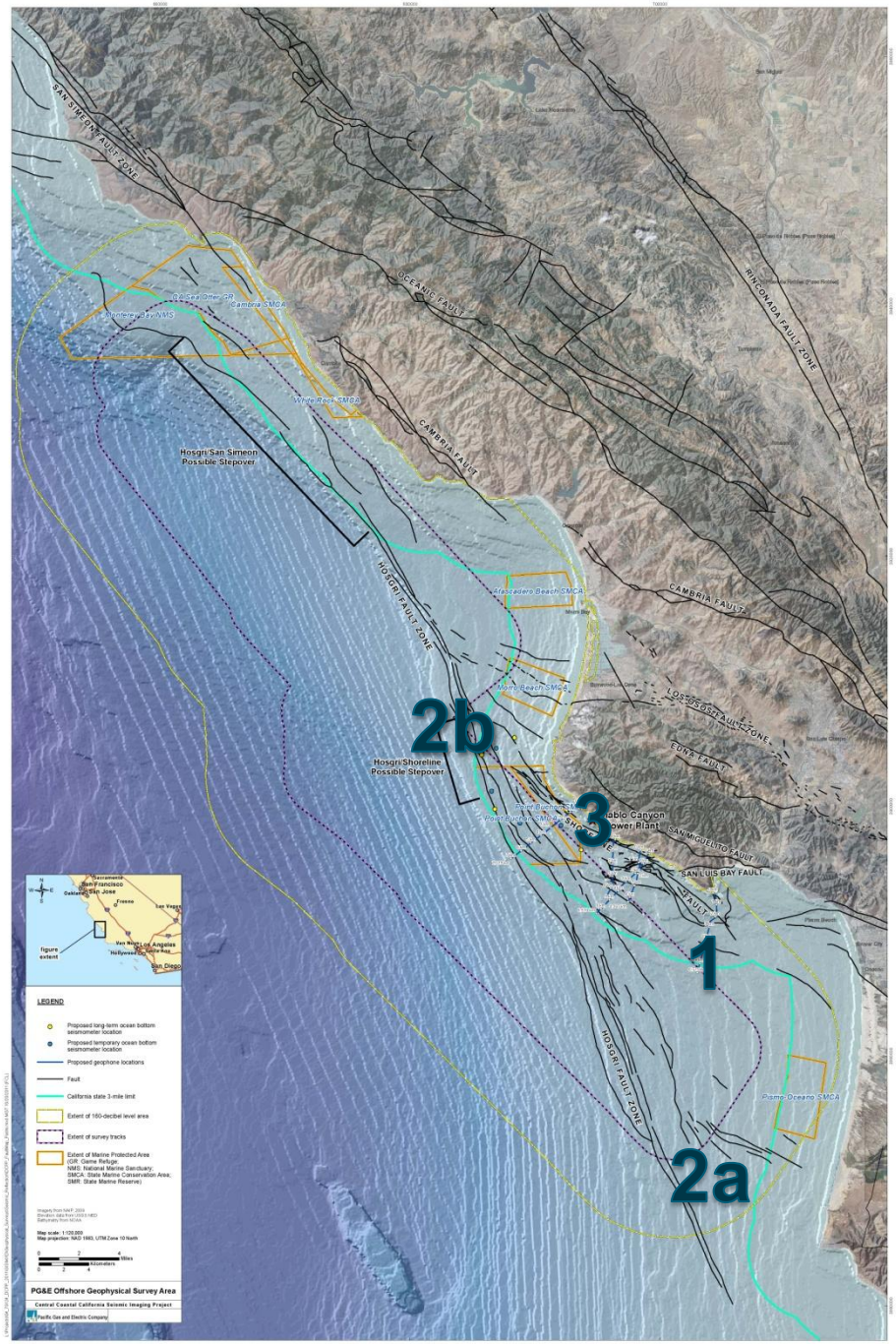
2. 2D/3D Low Energy Seismic Surveys (LESS) - Shoreline Fault Zone

3. 2D/3D Onshore Seismic Reflection Surveys - Irish Hills/ Los Osos Valley

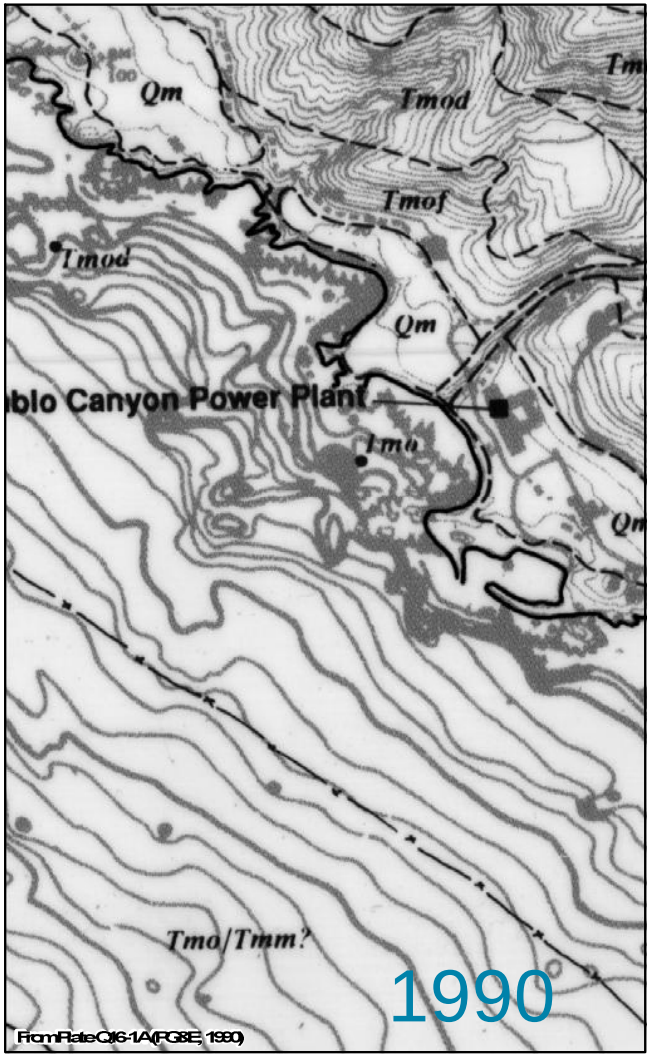


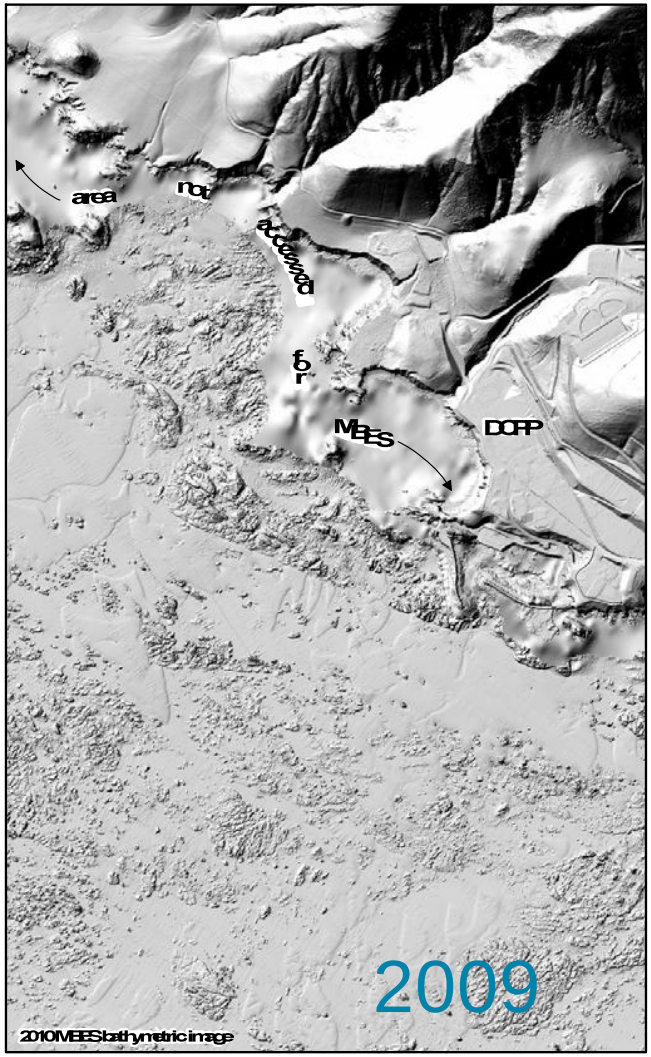
Central Coastal California Seismic Imaging Project 2012

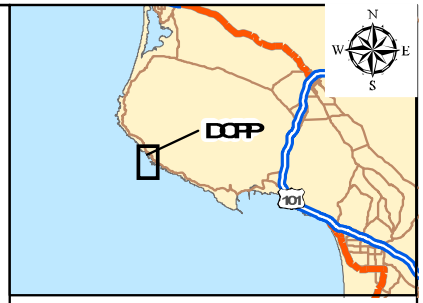
1. 3D LESS – Southern Shoreline Fault Zone
2. 3D LESS – Hosgri Fault Zone
3. 2D/3D Onshore Seismic – Western Irish Hills



Bathymetric Mapping







Map scale: 1:15,000
Map projection: NAD 1983, UTM Zone 10 North

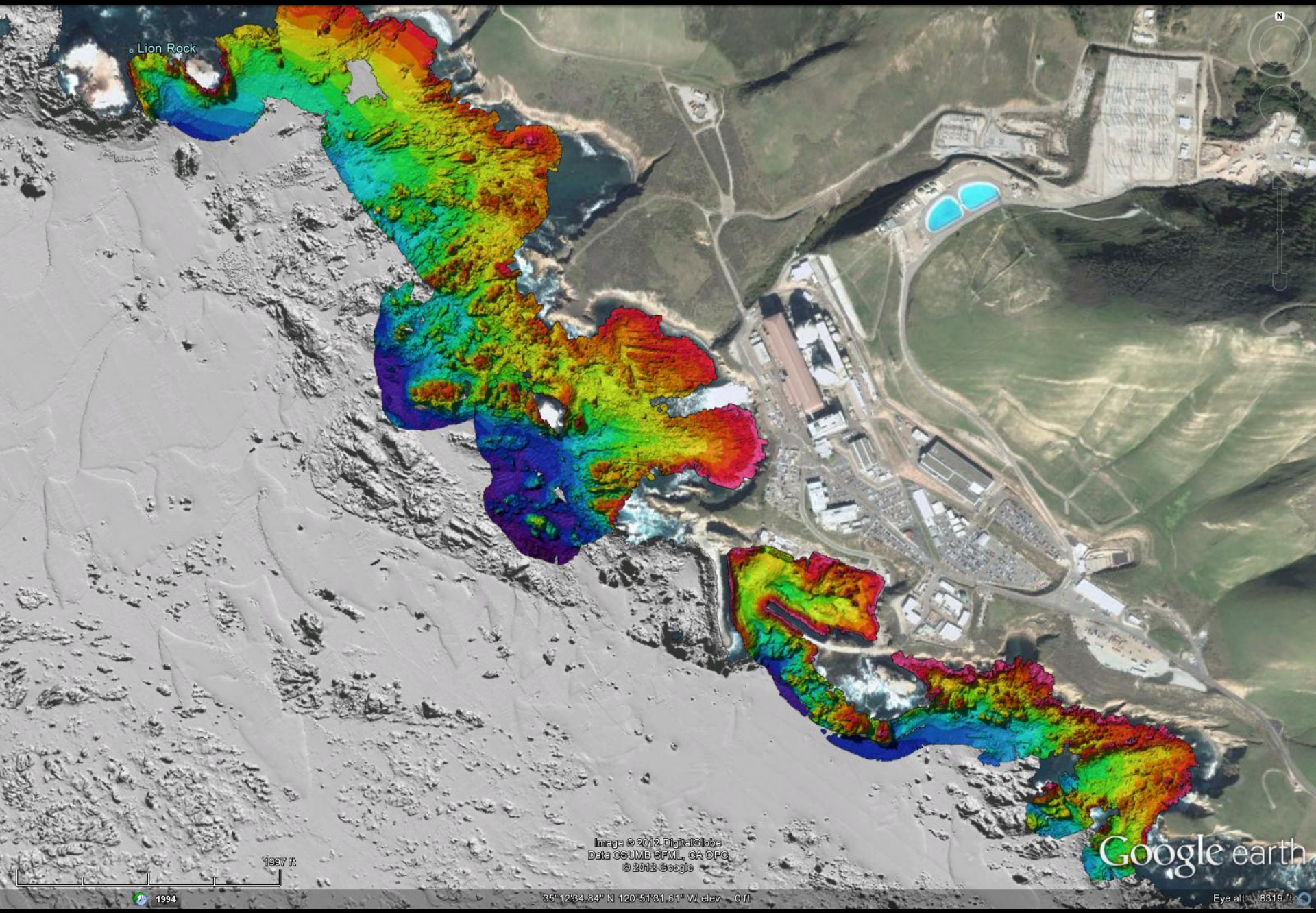
0 0.1 0.2 0.3 0.4 0.5 Miles
0 0.2 0.4 0.6 0.8 Kilometers

Comparison of 1990 LTSP bathymetry with the 2009 MBES bathymetry – offshore DCPP area

SHORELINE FAULT ZONE STUDY

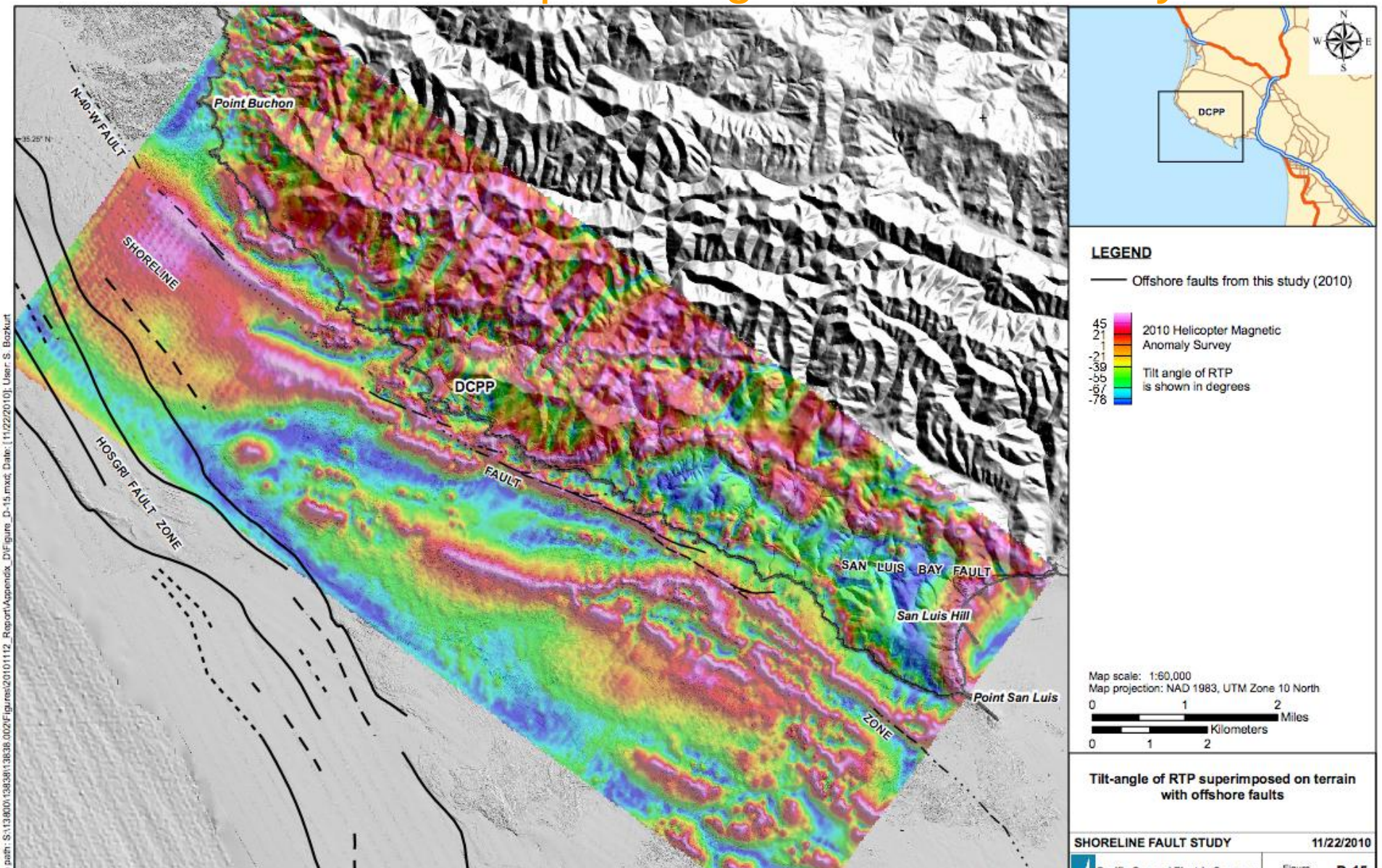
Pacific Gas and Electric Company | Figure F-2

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Figure_2-6.mxd: Date: [12/21/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.

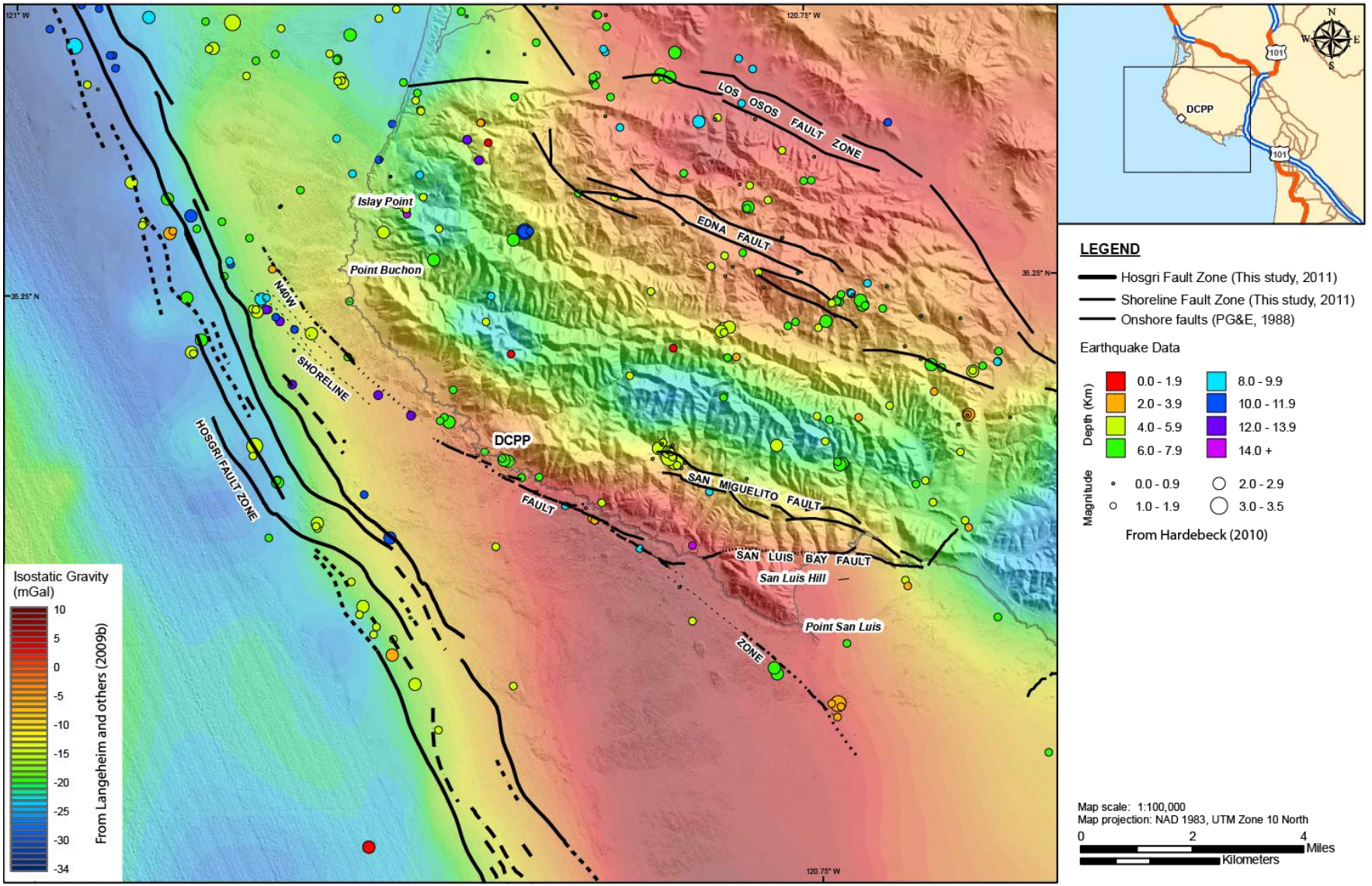

Lion Rock
Image © 2012 DigitalGlobe
Data CSUMB SFML, GA OPC
© 2012 Google
Google earth
1997 ft
1994
35°12'34.84" N 120°51'31.61" W elev 0 ft
Eye alt 8319 ft

Potential Field Mapping

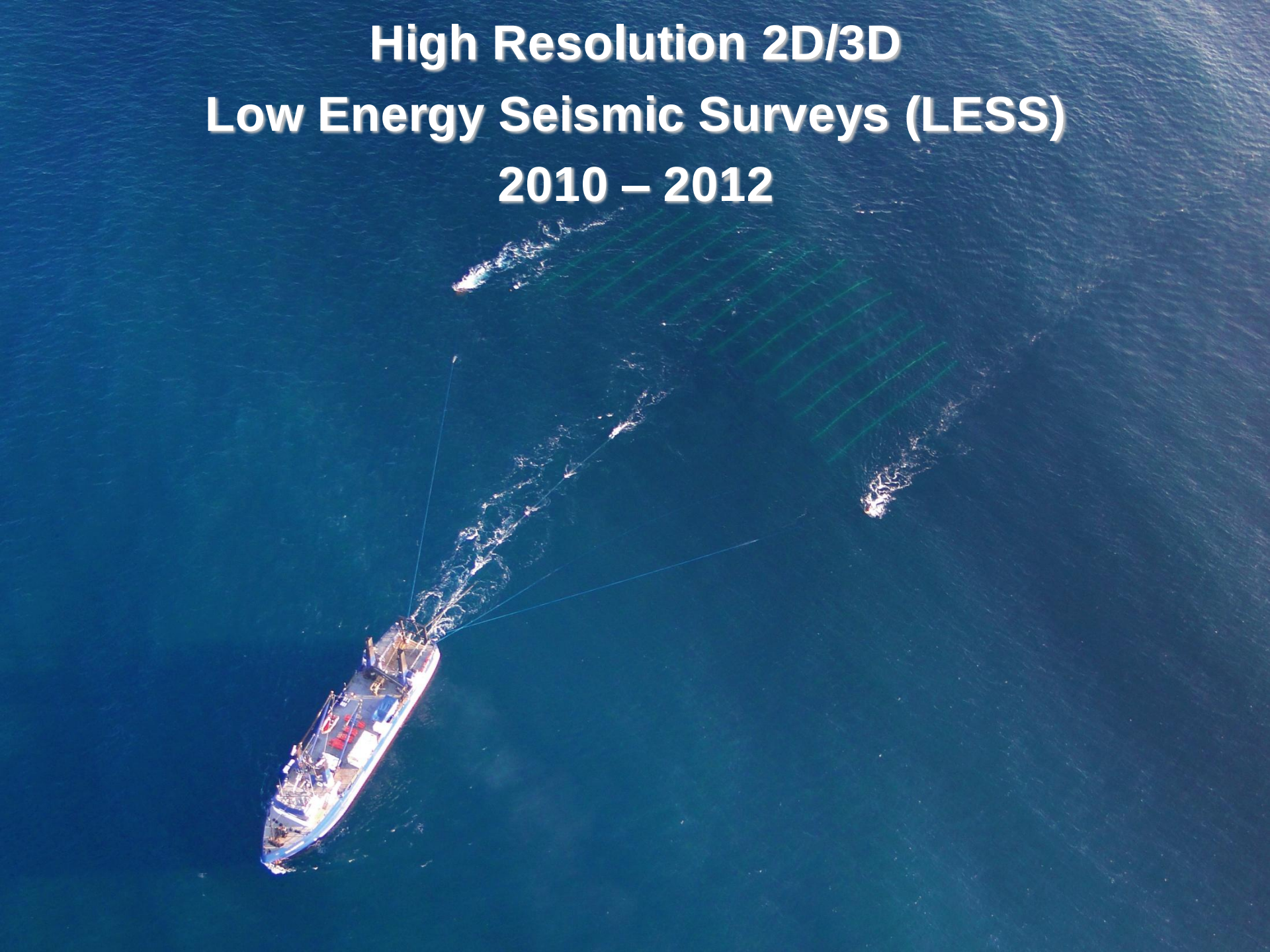
2010 Helicopter Magnetic Field Survey



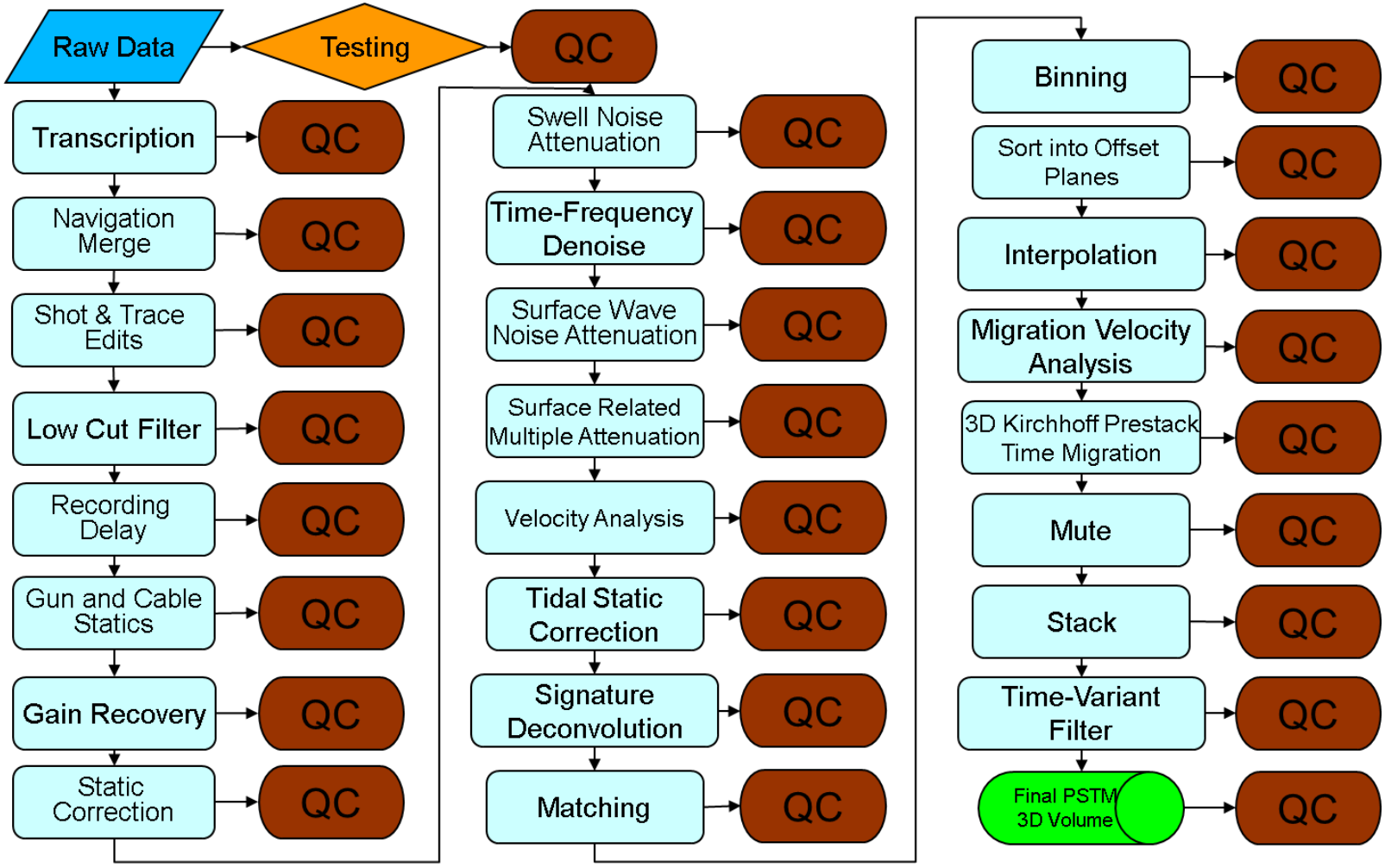
Earthquake Epicenters
Isostatic Gravity Field



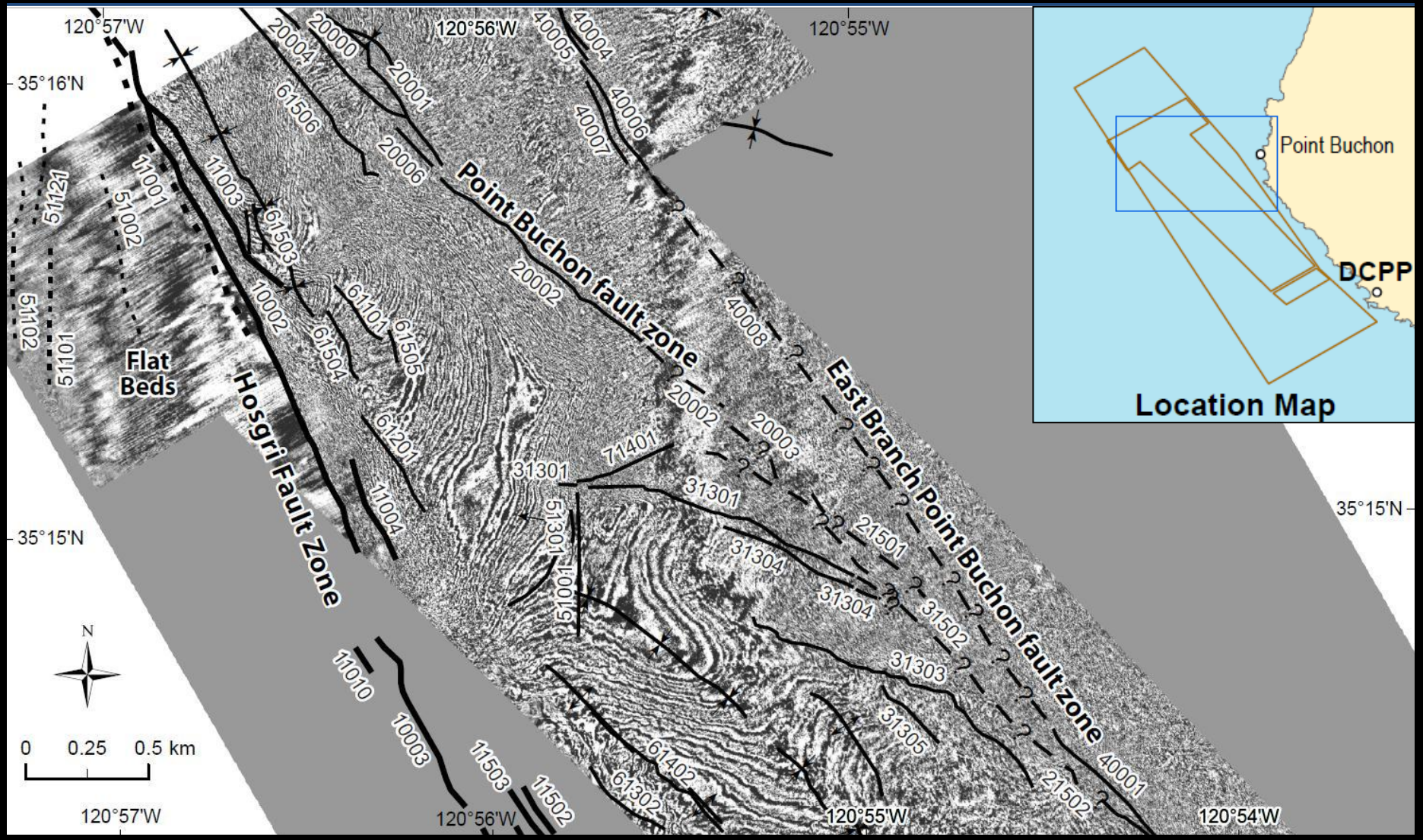
High Resolution 2D/3D
Low Energy Seismic Surveys (LESS)
2010 – 2012



3D Data Processing Flow

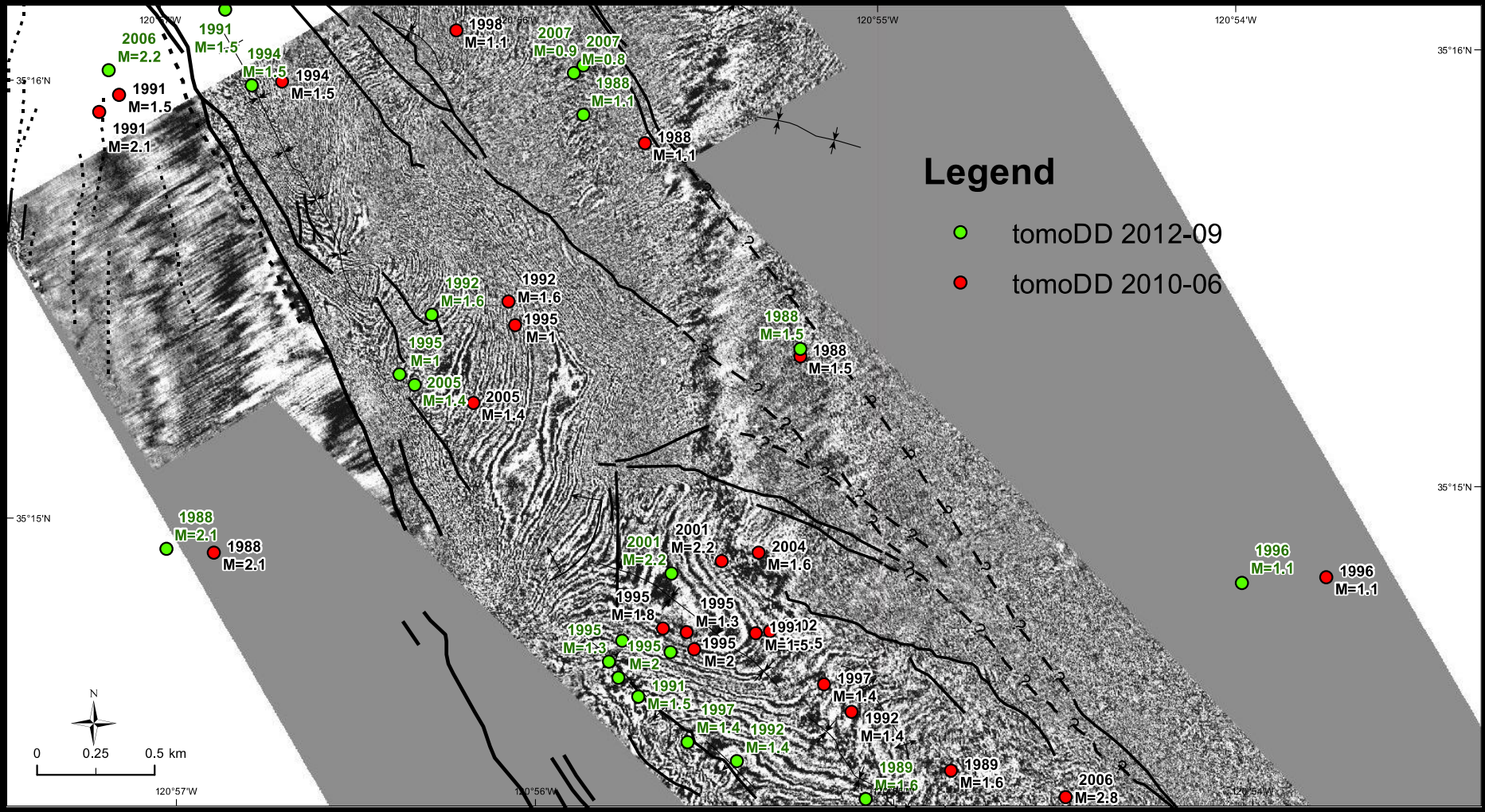


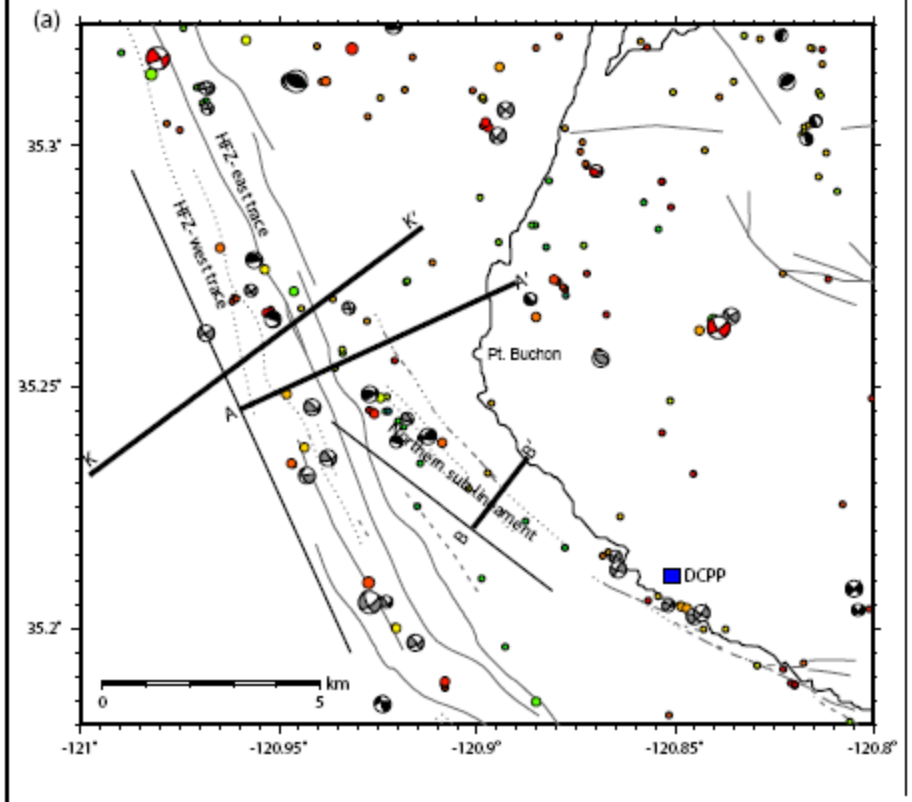
3D LESS Amplitude Time Section

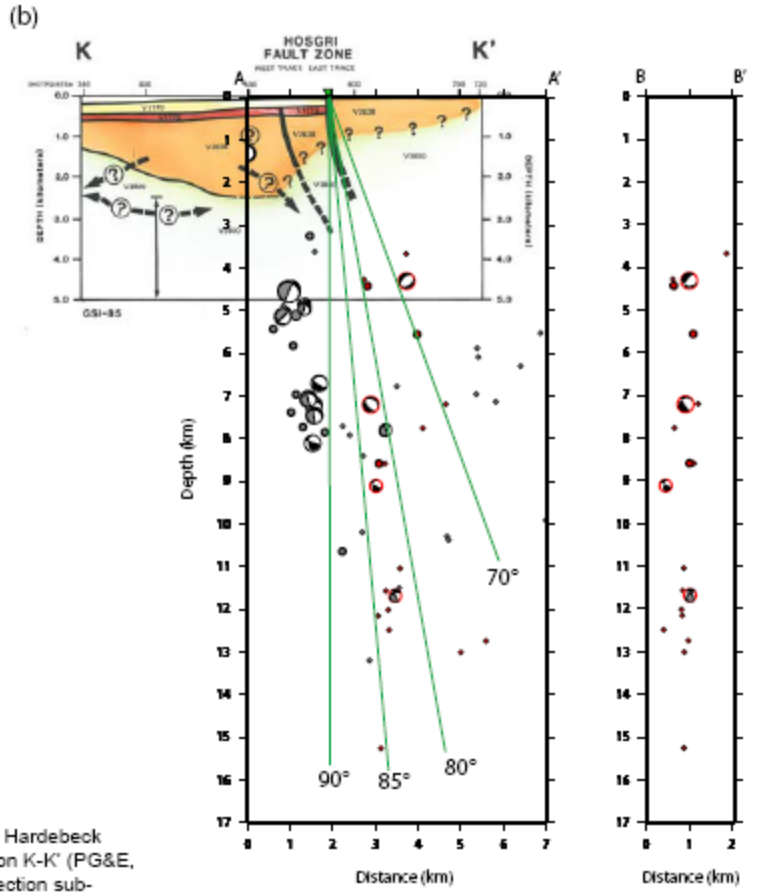


Time Slice @ 150 ms, ~ 115 m depth

Comparison of 2010 and 2012 seismicity catalogs with LESS Amplitude Time Section







Earthquake Magnitudes
depth
• < 2.0
o 2.0 - 2.99
O 3.0 - 3.99
0
2
4
6
8
10
12
14
16
18
km

Focal Mechanisms
<2.0
2.0 - 2.9
3.0 - 3.9
Hash Quality A,B,C
Hardebeck, 2010 (HASH; Hardebeck and Shearer, 2002)
Hash Quality D
Hardebeck, 2010 (HASH; Hardebeck and Shearer, 2002)
FPFIT
NCEDC, 2010 (FPFIT; Reasenberg and Oppenheimer, 1985)

Reverse
Normal
Strike-Slip

Earthquake relocations from Hardebeck (2010). Seismic depth section K-K' (PG&E, 1988), is projected to A-A' section sub-parrallel to Hosgri fault zone. Possible Hosgri fault zone dip angles are shown on BB'. Focal mechanisms are from 1-D (FPFIT) and 3-D (HASH) locations. Focal Mechanism symbols are associated with adjacent earthquake locations.

Northern sub-lineament earthquakes (red dots and red circled focal mechanisms) are shown on both cross sections .

(a) Seismicity map and (b) cross sections A-A' across the east and west traces of the Hosgri fault zone (HFZ), and B-B' across the Shoreline Northern sub-lineament. Interpreted seismic depth section K-K' is also shown.

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company

Figure 4-8

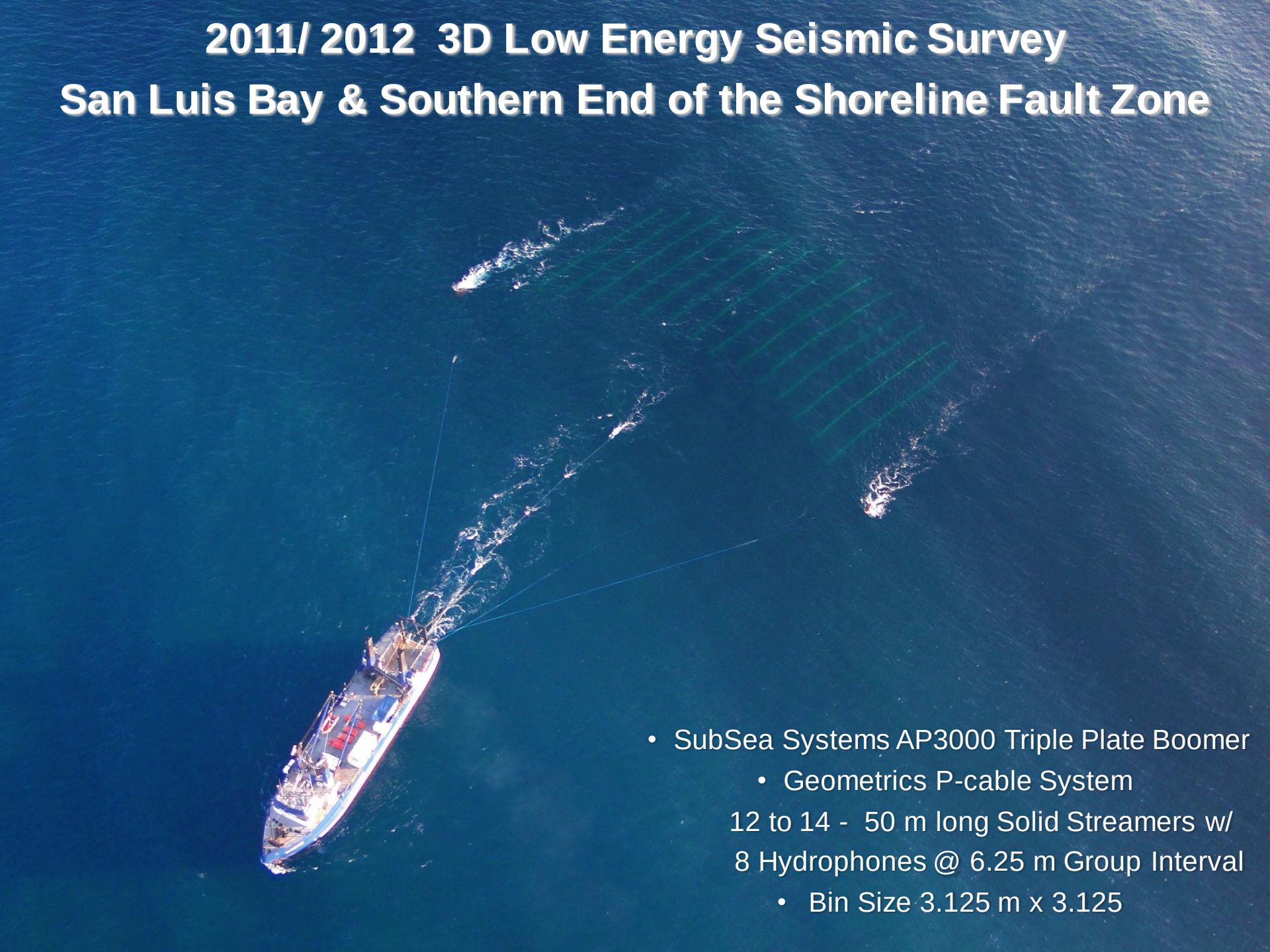
DCPP 3D/2D Seismic-Reflection Investigation of Structures Associated with the Northern Shoreline Seismicity Sublineament of the Point Buchon Region

PG&E GEO.DCPP.TR.12.01 R0

Technical Report describing the 2010/2011 2D/3D survey of the northern segment of the Shoreline Fault was released in 2012 and transmitted to the PUC IPRP as well as the SSHAC study team.

The Technical Report and associated LESS data are available at http://www.pge.com/dcpp-ltsp

2011/ 2012 3D Low Energy Seismic Survey
San Luis Bay & Southern End of the Shoreline Fault Zone



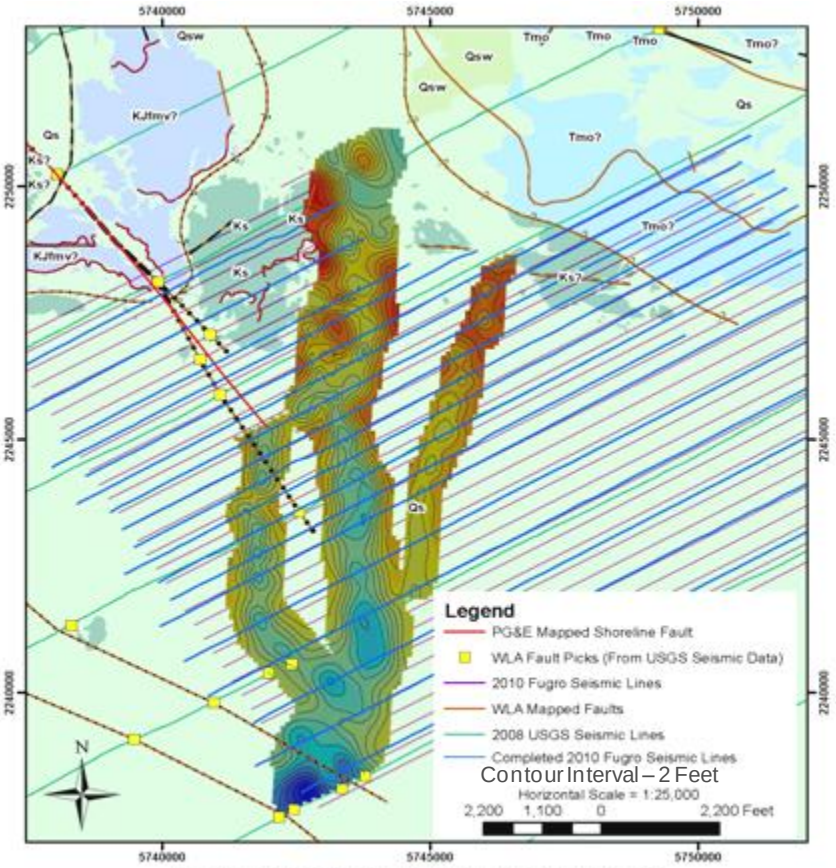
- SubSea Systems AP3000 Triple Plate Boomer
- Geometrics P-cable System

12 to 14 - 50 m long Solid Streamers w/
8 Hydrophones @ 6.25 m Group Interval

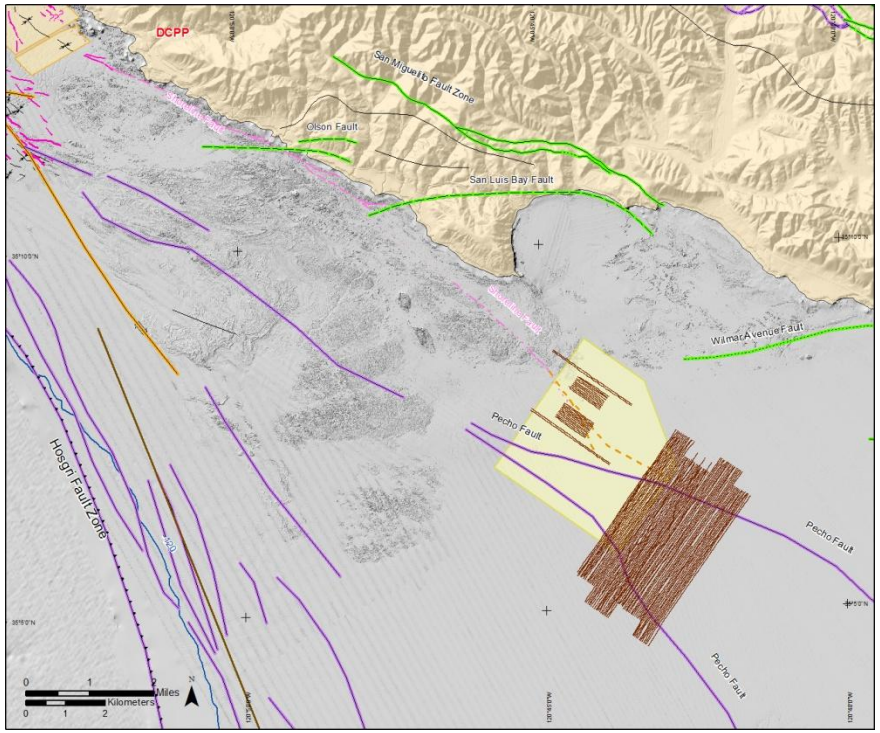
- Bin Size 3.125 m x 3.125

2011/ 2012 3D LESS Southern End of Shoreline Fault Zone

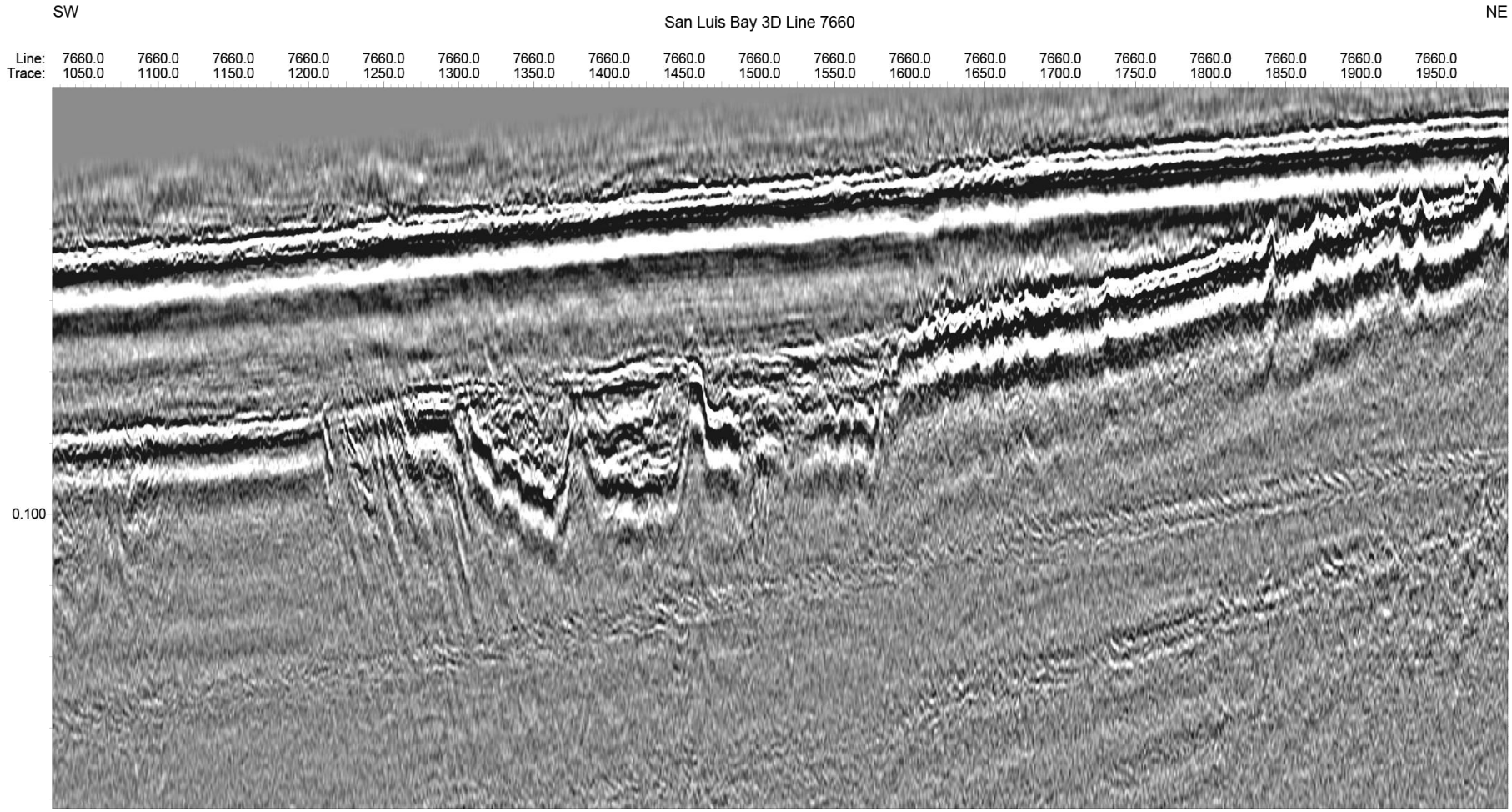
San Luis Bay



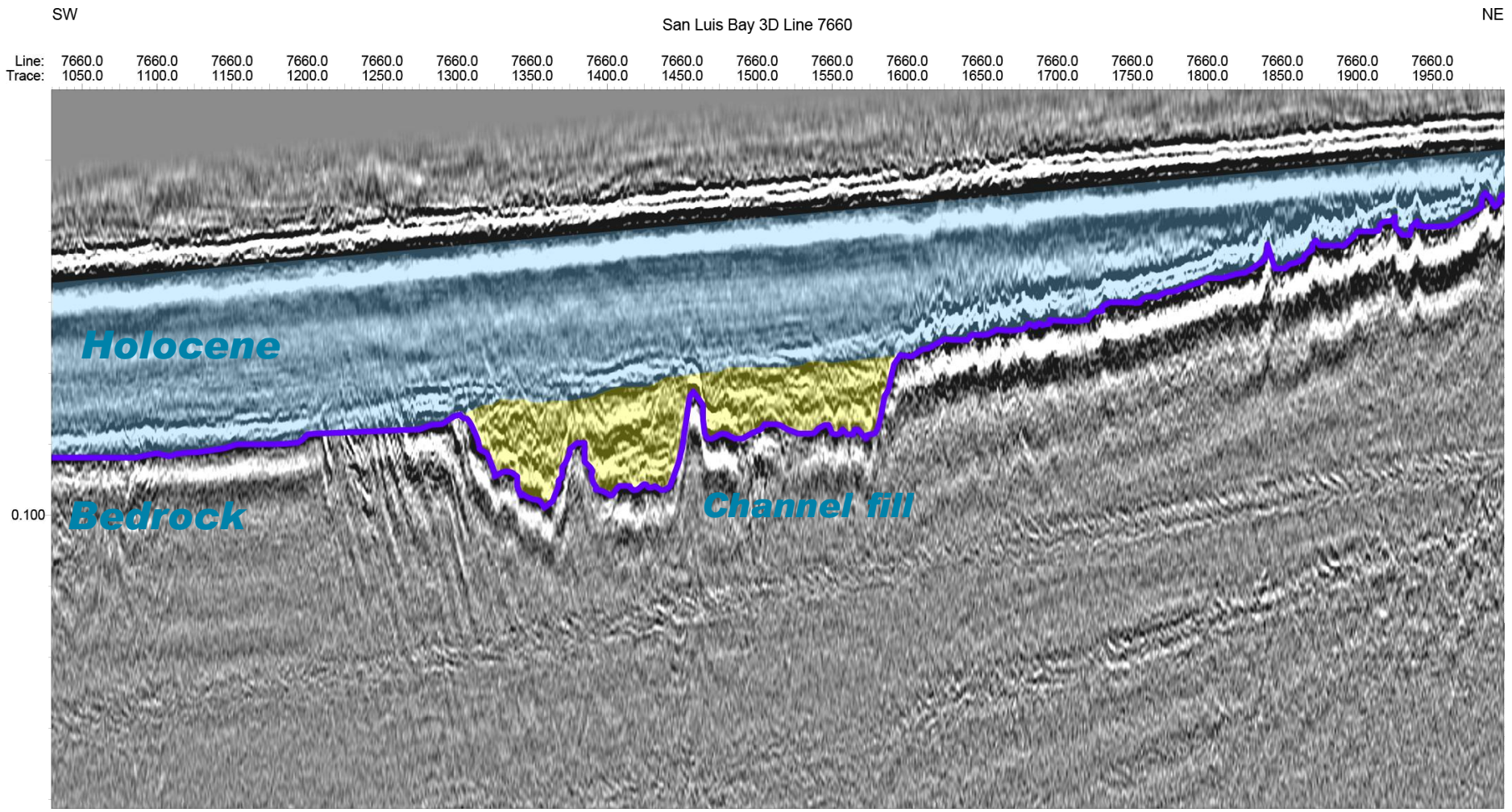
MAPPED PALEOCHANNELS WITHIN SURVEY AREA 2
PG&E 3D SEISMIC REFLECTION SURVEYS
Offshore Central California



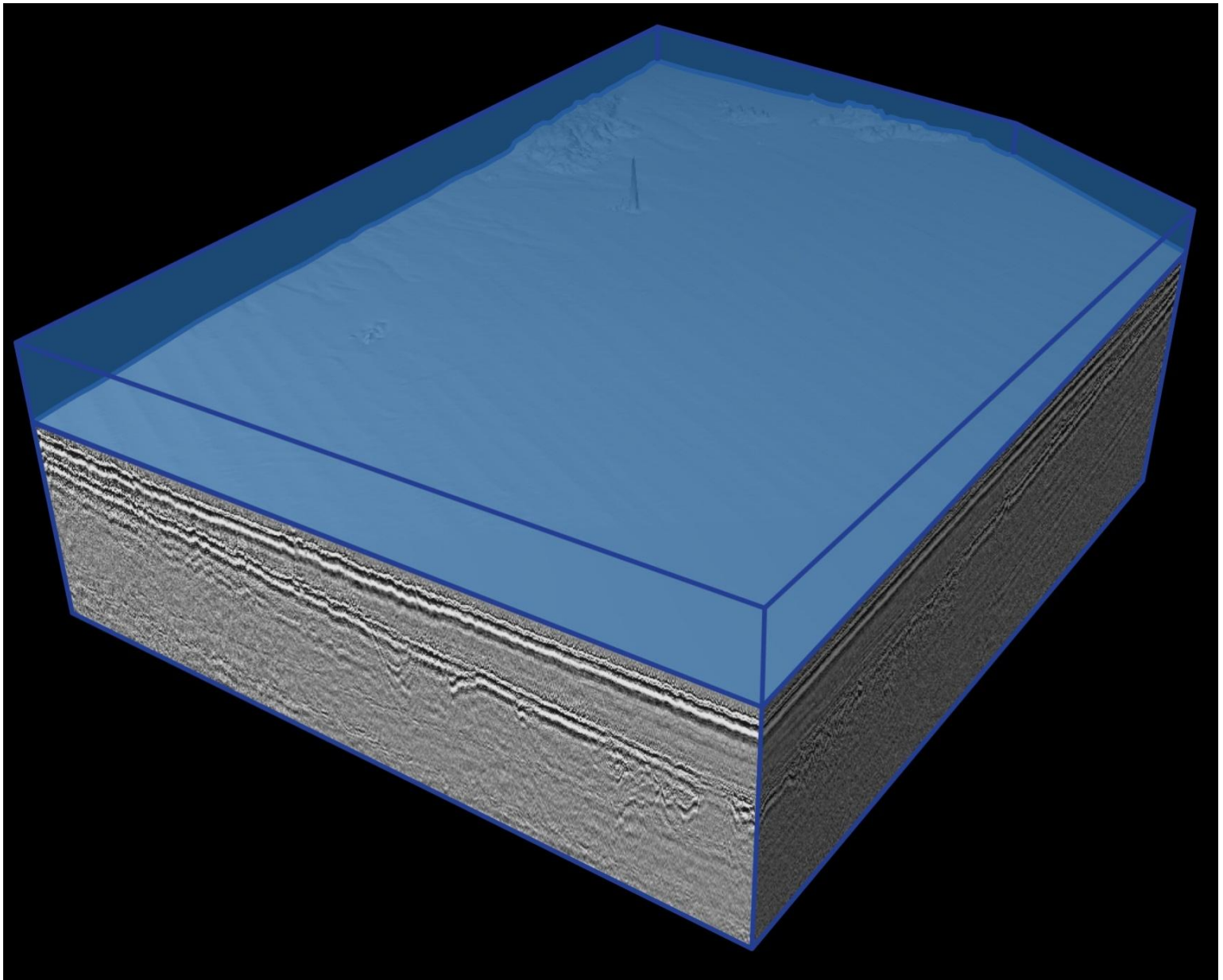
San Luis Bay 3D Line 7660
Uninterpreted



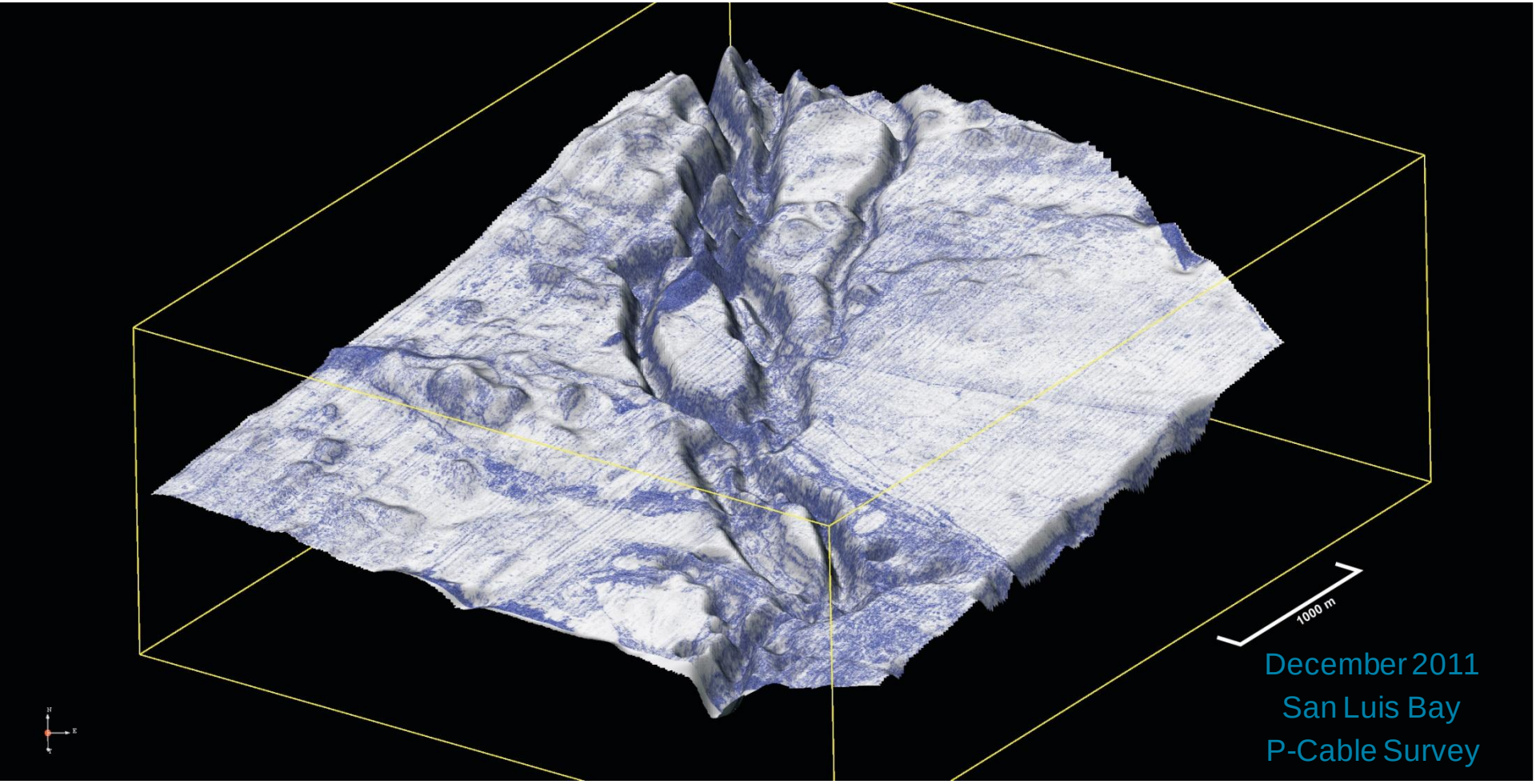
San Luis Bay 3D Line 7660
Interpreted

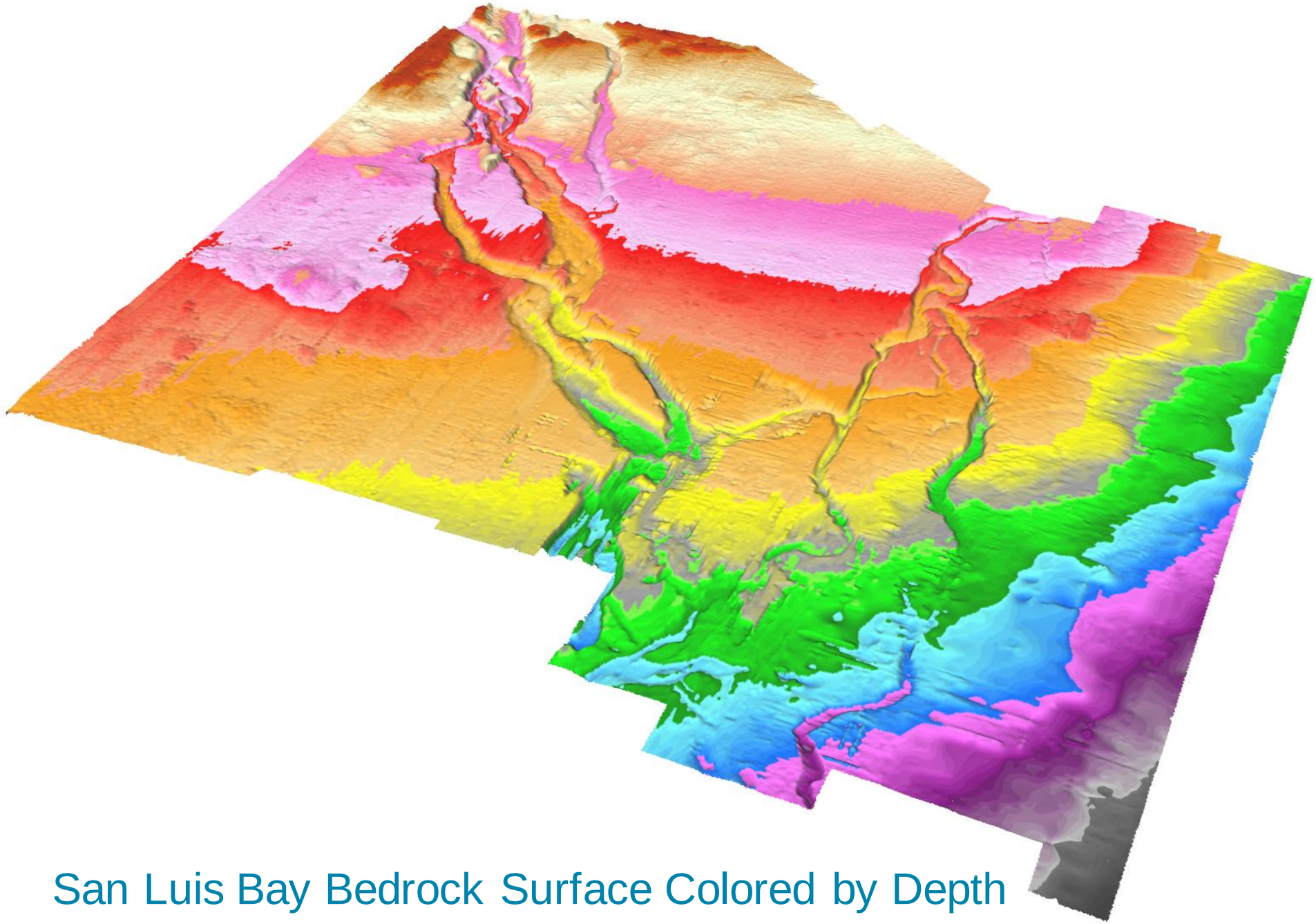


San Luis Bay 3D P-Cable Survey
Block Diagram Animation



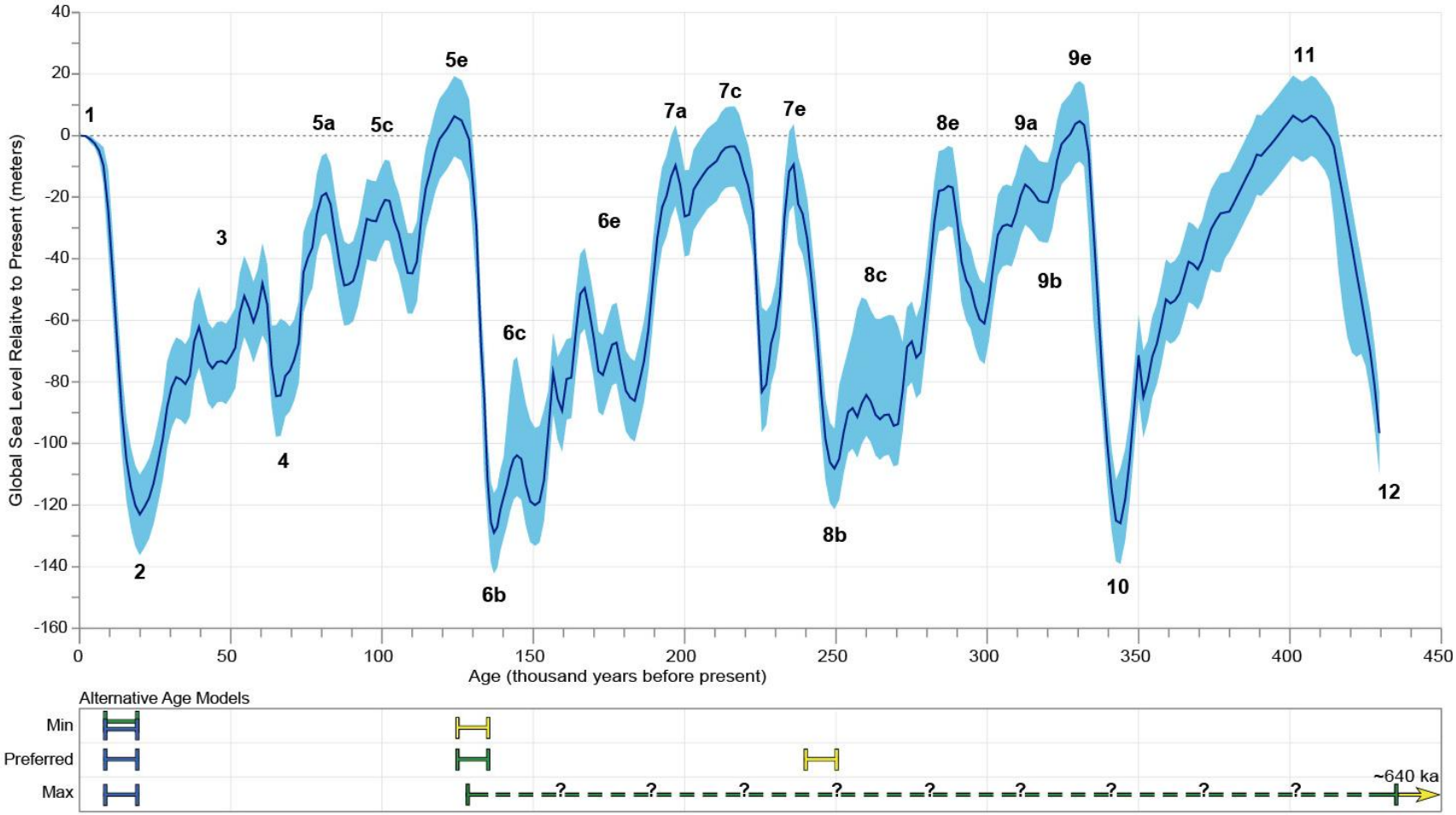
Perspective View of Bedrock Surface
Smoothed Dip of Maximum Similarity





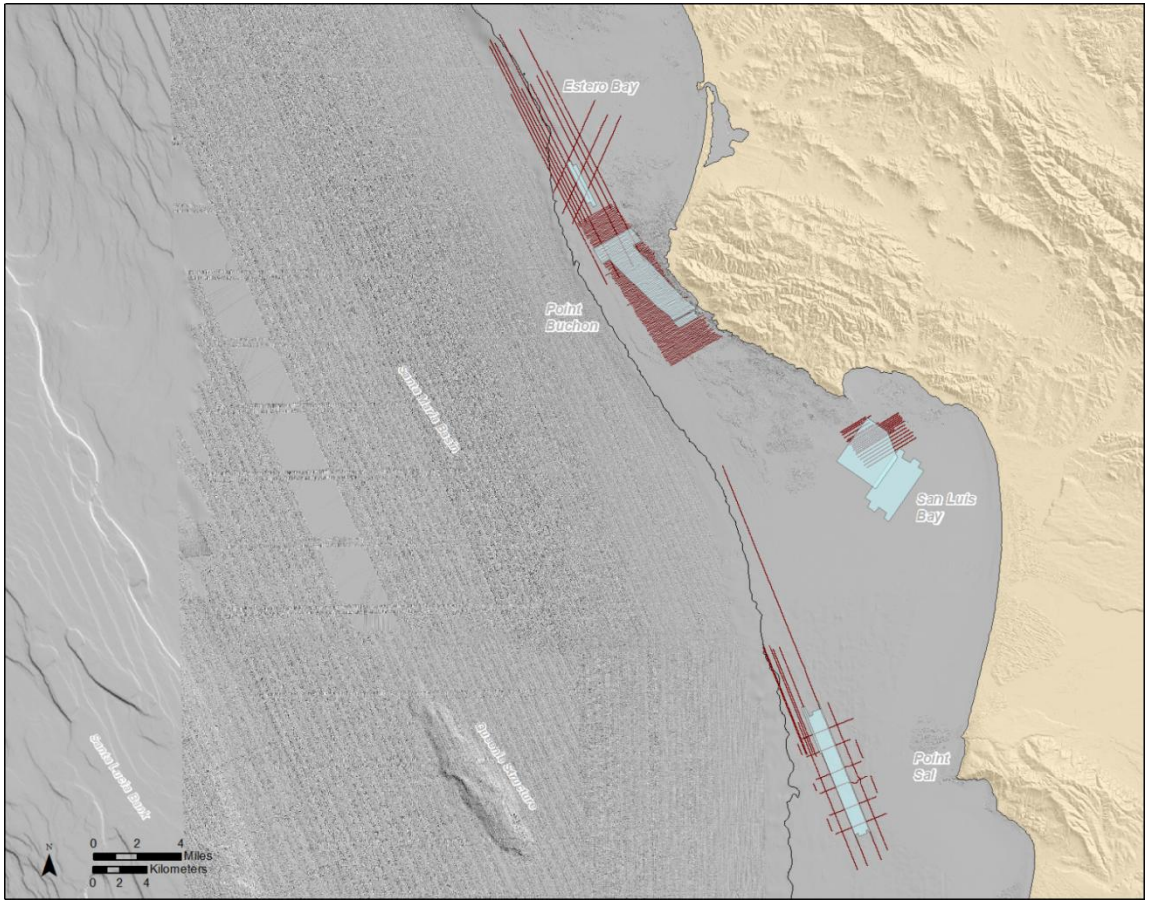
San Luis Bay Bedrock Surface Colored by Depth

Reconstructed Sea Level Curve Past 430 ka

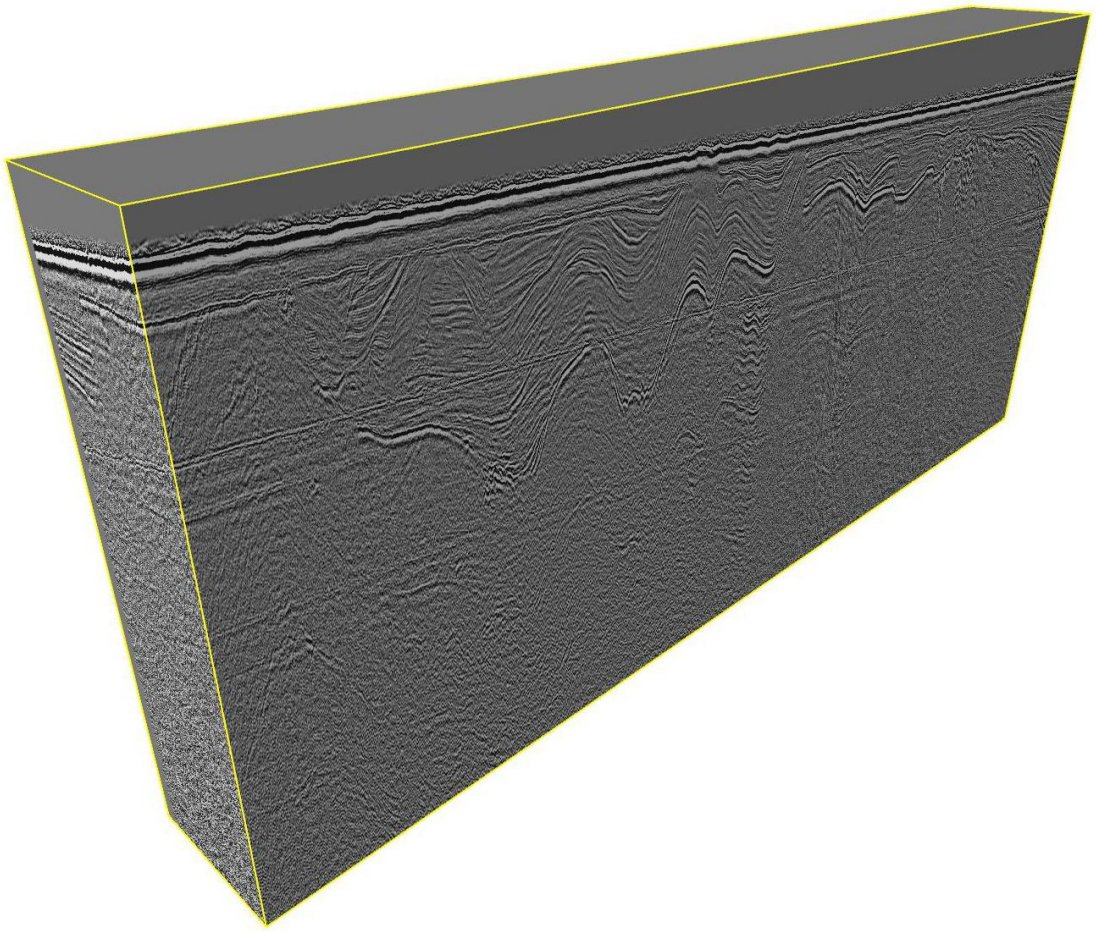


(Modified from Waelbroeck et al., 2002)

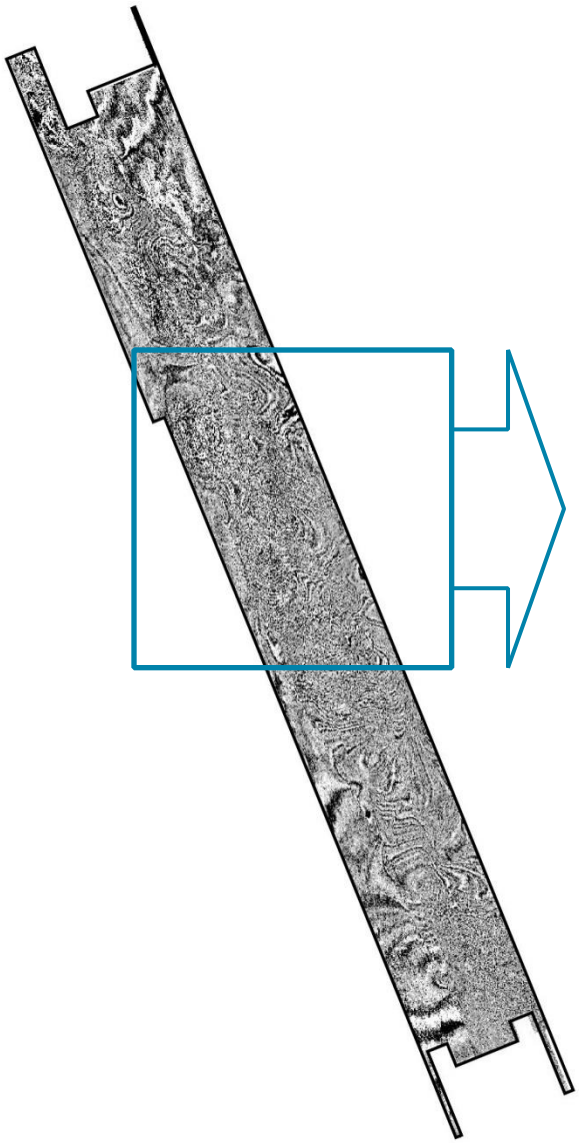
2010-2012 2D/3D Low-Energy Seismic Survey Tracklines

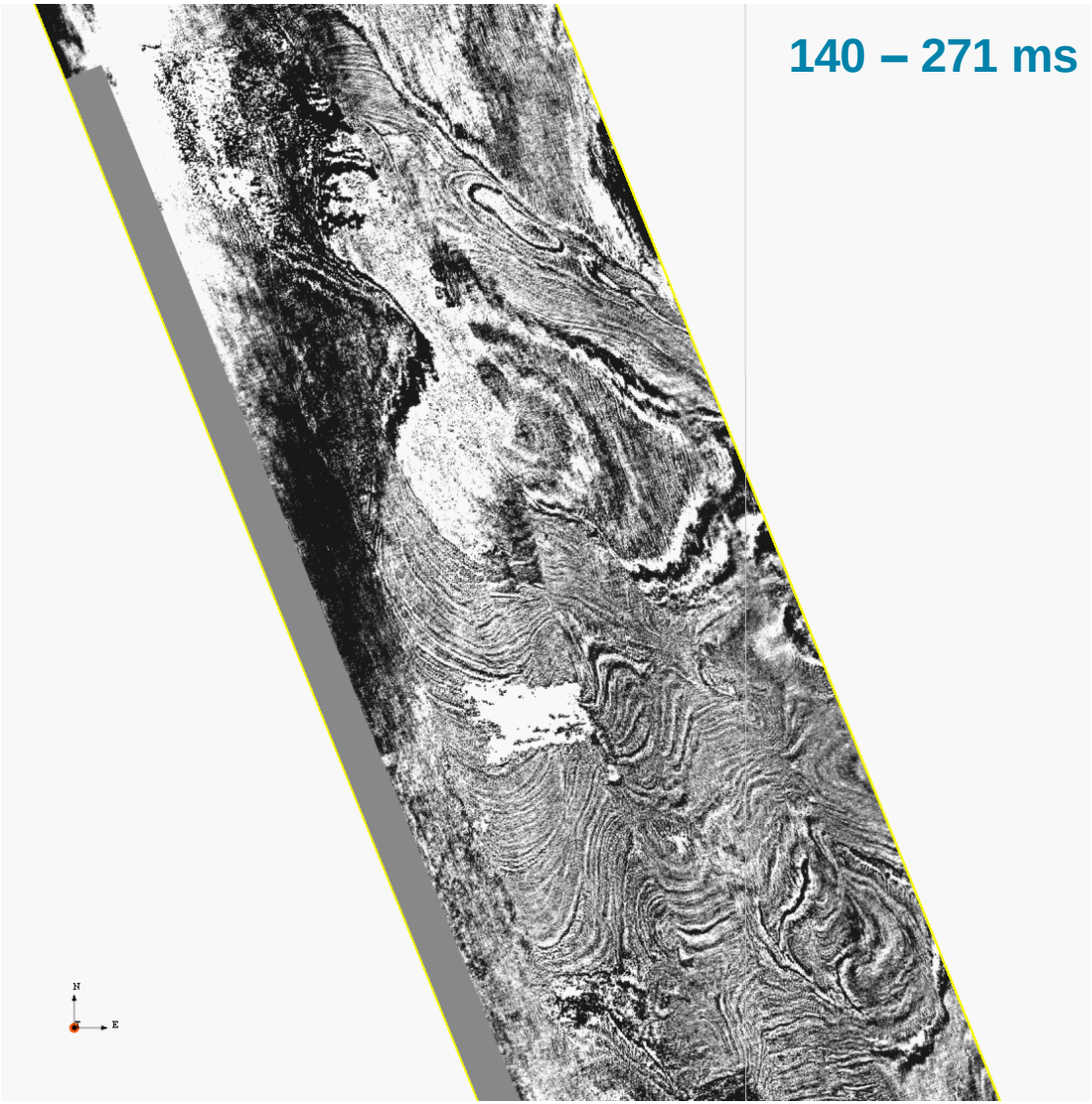


Point Sal 3D Amplitude Volume

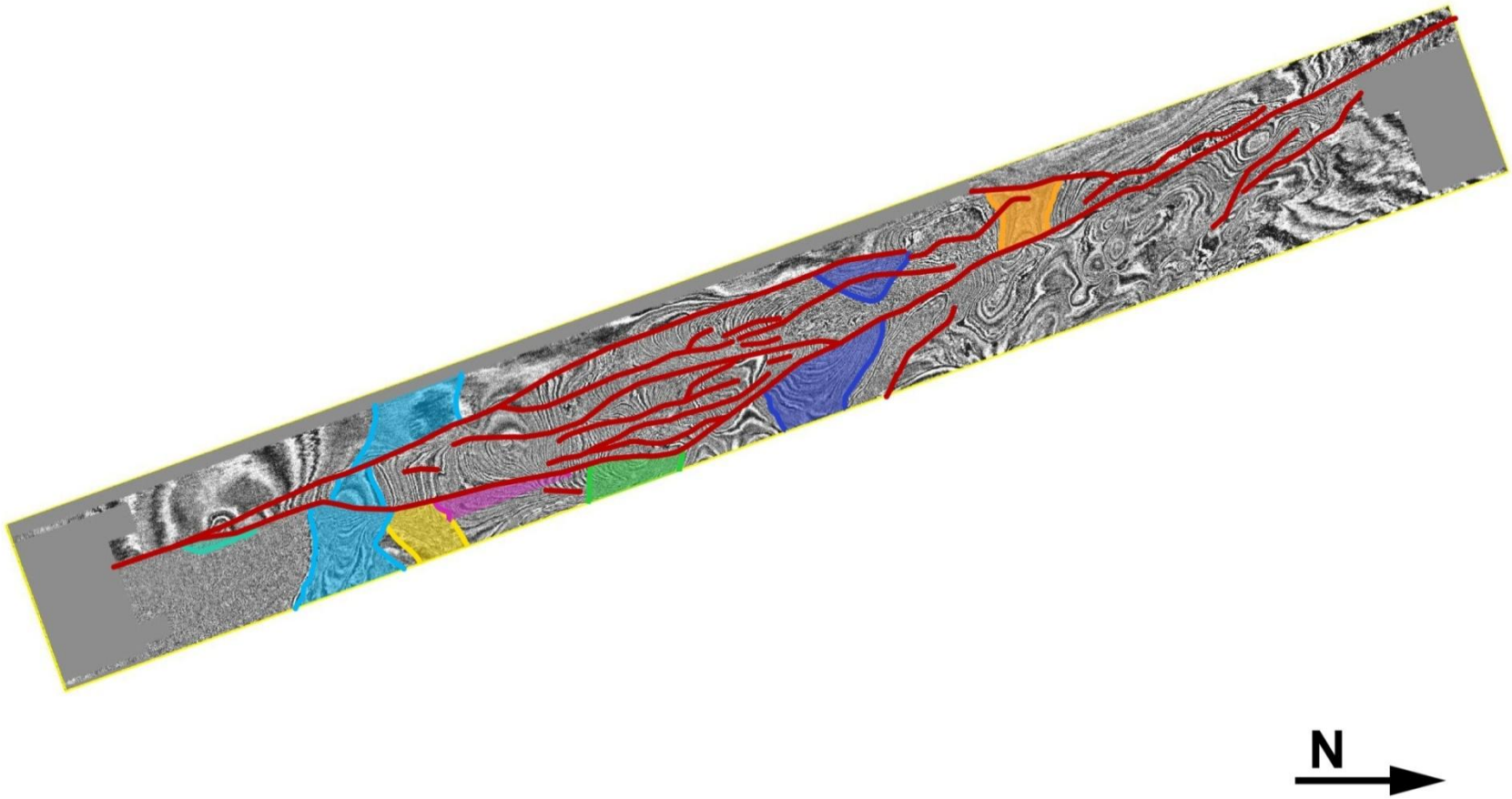


Time Slice Animation





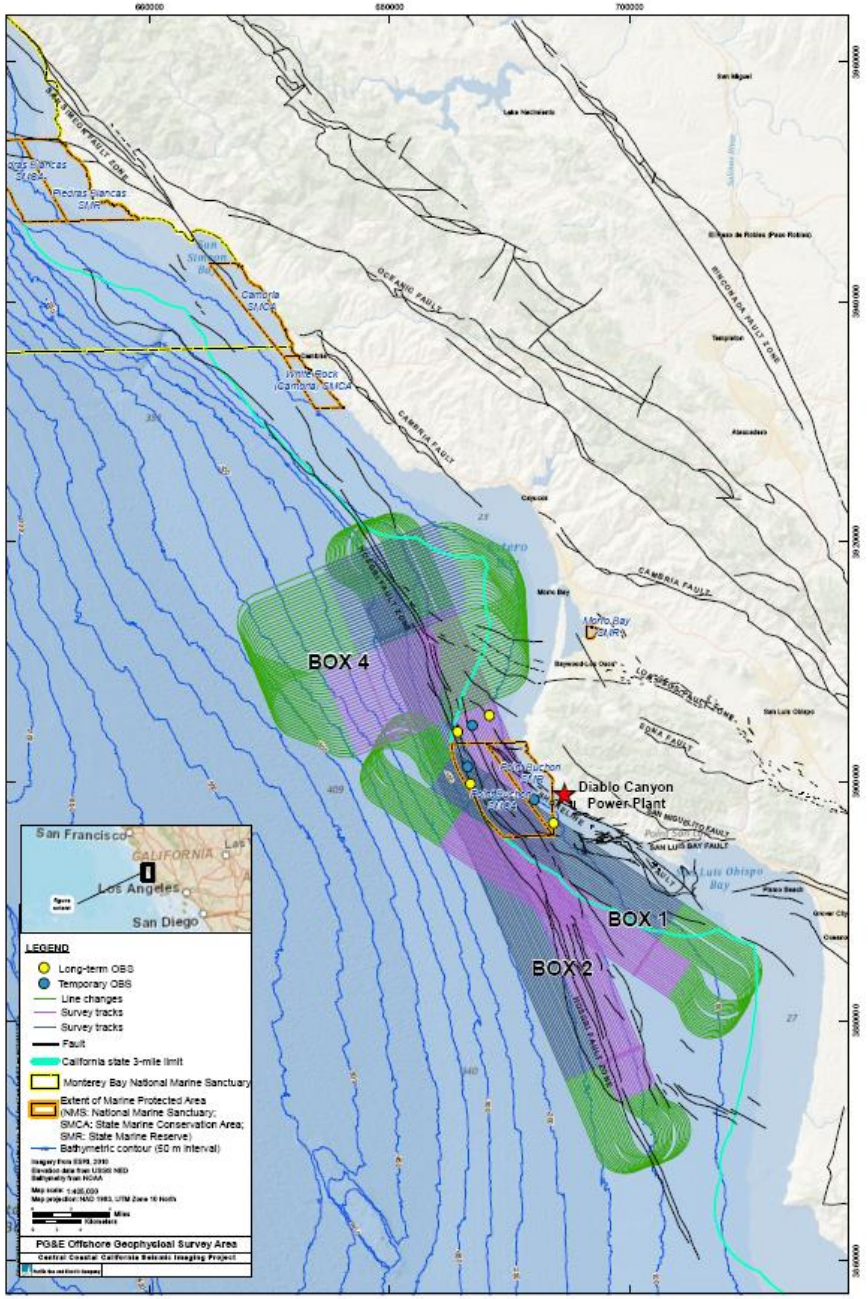
Paleochannels and Faults Plan View



Technical Reports describing the
2011 and 2012 Low Energy Seismic Surveys of the
southern segment of the Shoreline Fault Zone and the
Hosgri Fault Zone will be issued in the fourth quarter of 2013.

Proposed
3D High Energy Seismic Survey (HESS)

R/ V Marcus Langseth



May 2011

PG&E files for CA State Lands Commission Geophysical Survey Permit

Environmental Impact Report process begins

July 2011

PG&E issue RFP for geophysical survey vessel to conduct 3D HESS offshore DCPP.

2012

PG&E initiates Federal permit/ authorization process to conduct 3D HESS in Federal and state waters offshore DCPP.

Involves coordination with many agencies including SLC, CCC, NSF and NOAA National Marine Fisheries

EIR submitted to State Lands Commission

August 2012

Geophysical Survey Permit issued by the CA State Lands Commission

EIR certified

Initiate environmental monitoring programs

Initiate pre-mobilization activities for RV Langseth

NSF holds field hearings in SLO

November 2012

Coastal Development Permit denied by the CA Coastal Commission

Federal Incidental Harassment Authorization withdrawn

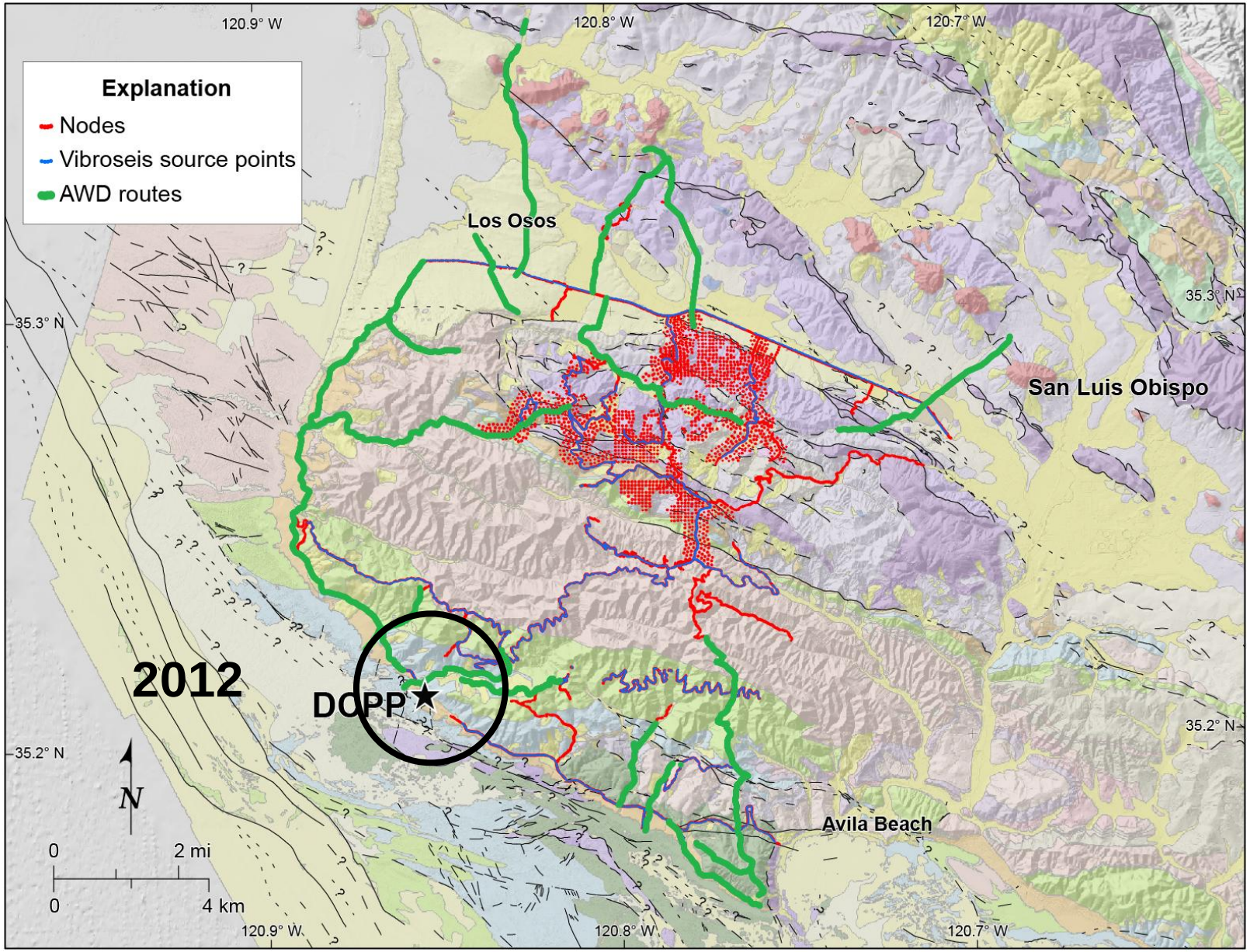
2013

Final decision on HESS studies pending review of existing data

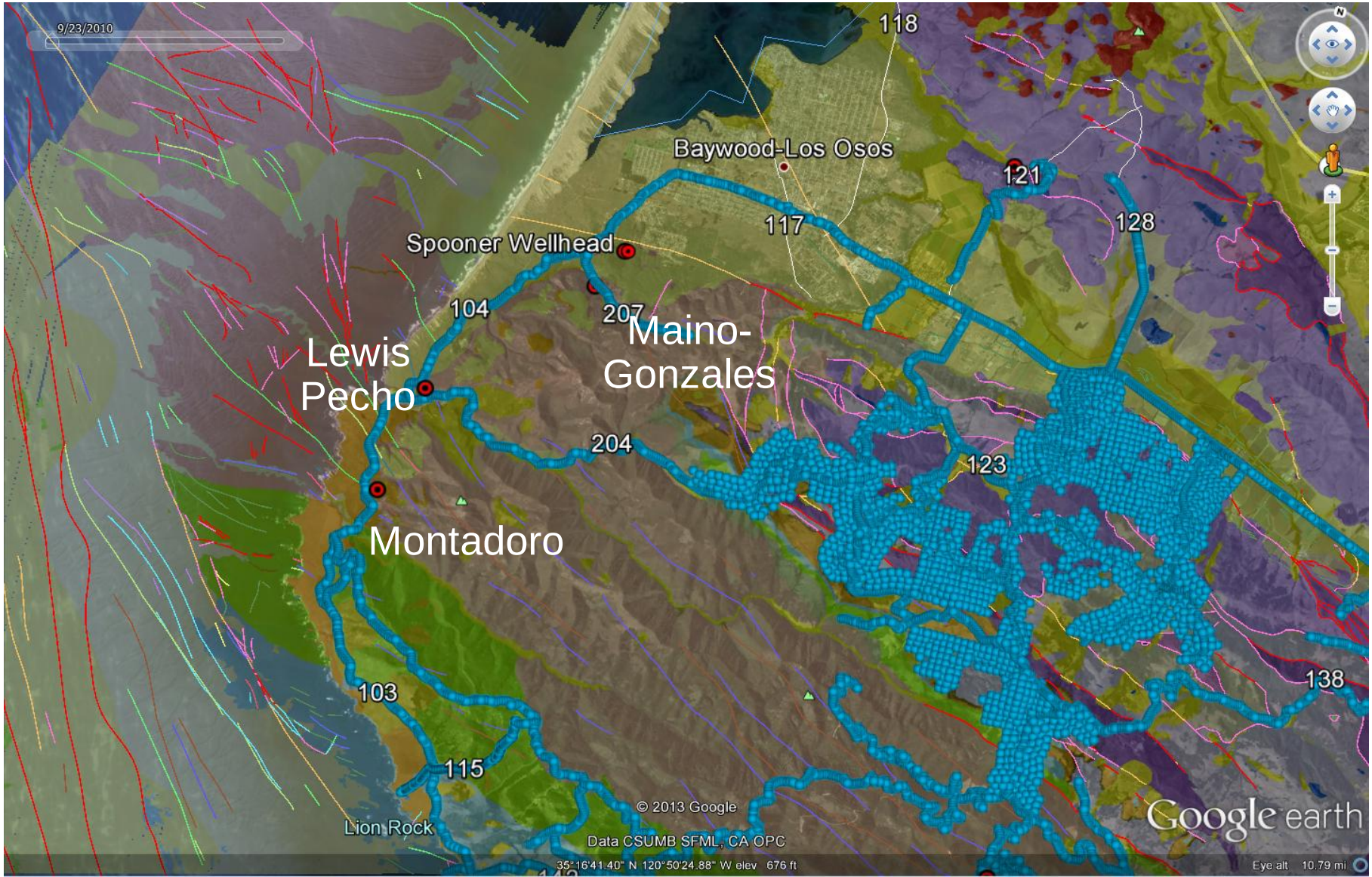
2D/3D Land Seismic Reflection Surveys

Irish Hills/ Los Osos Valley

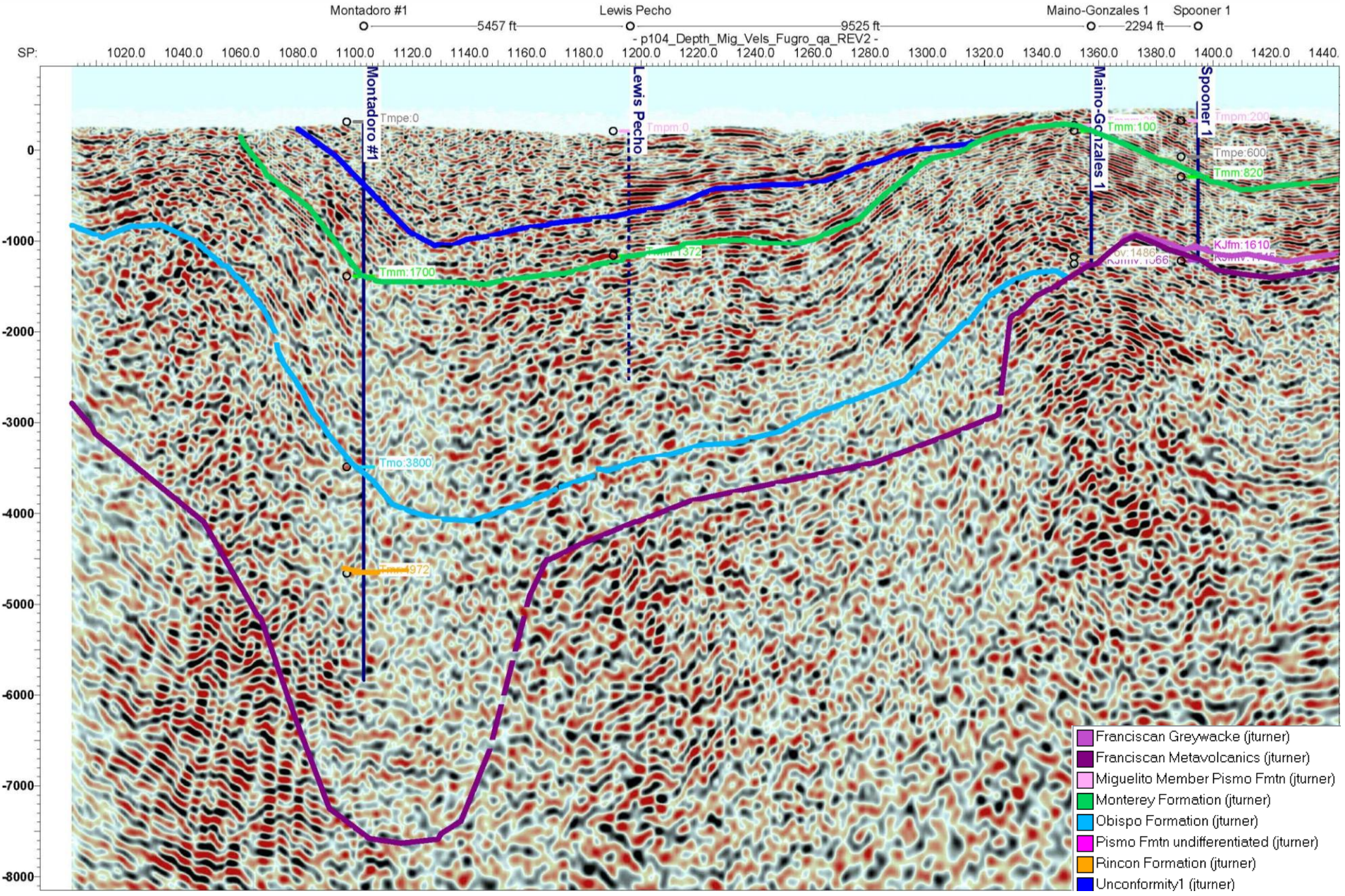
2011- 2012 2D/3D Seismic Reflection Surveys



P104 Well Coverage – 4 Wells with Stratigraphy

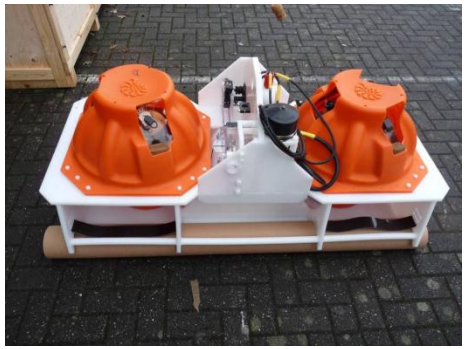


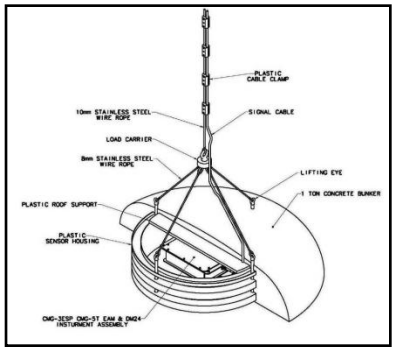
Depth Migrated Line P104 with Wells and Preliminary Stratigraphy

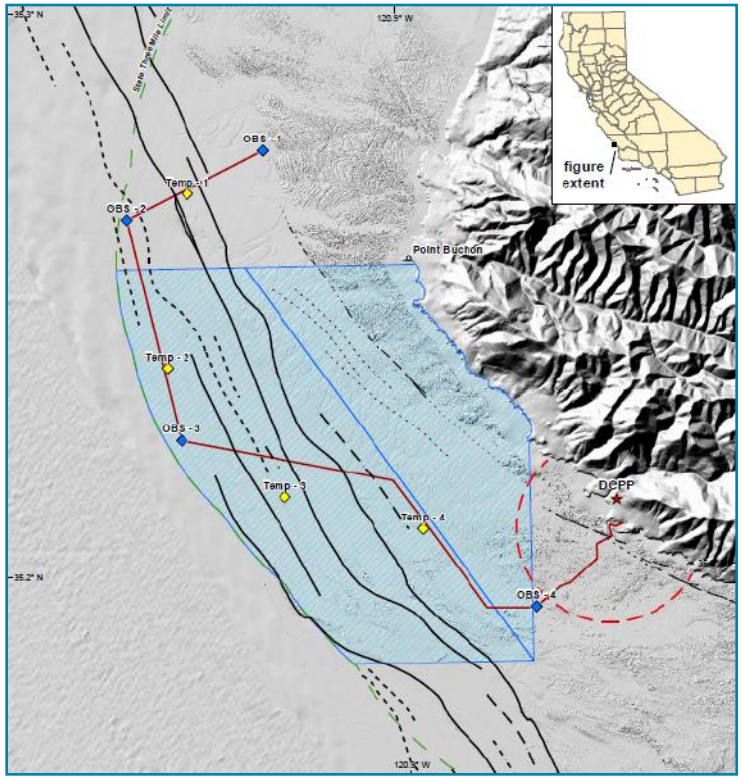


Technical Reports describing the
2011 and 2012 2D/3D Land Seismic Reflection Surveys
will be issued in the second quarter of 2014.

Ocean Bottom Seismometers







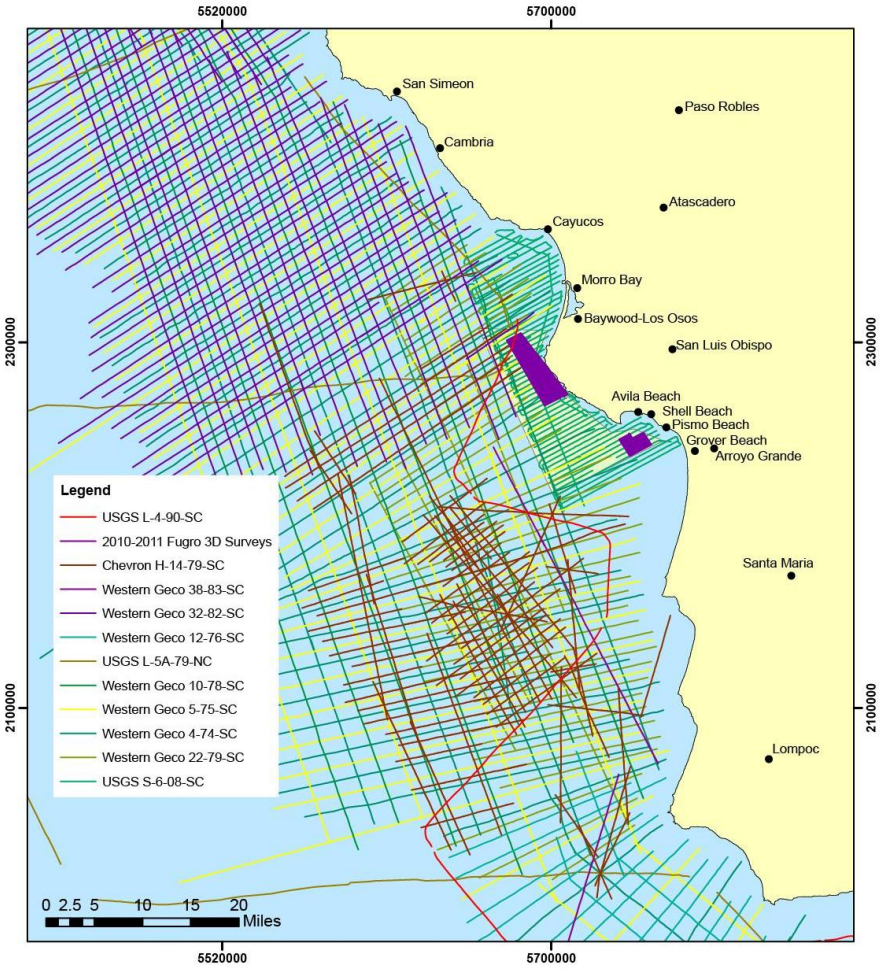
PG&E has applied for and received the necessary state and Federal permits to deploy and operate a network of four (4) Ocean Bottom Seismometers (OBS) offshore Point Buchon.

The objective of the OBS network is to improve the detection capability and location accuracy of earthquakes in this region.

OBS instruments are scheduled to be deployed in the third quarter of 2013

Legacy Data Archive

- Earthquakes
- Geology
- GPS
- LiDAR
- Multi Beam Echo Sounding
- Potential Field (Magnetics/ Gravity)
- Seismic Reflection/ Refraction



SEISMIC DATA AVAILABLE OFFSHORE CENTRAL CALIFORNIA
PG&E 3D Seismic Reflection Surveys
Offshore Central California

http://www.pge.com/dcpp-ltsp

Thank You !